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"EVALUATION OF PLATELET INDICES IN TYPE 2 DIABETES MELLITUS"

DR GEETANJALI YADAV

UNDER SUPERVISION OF

DR ADREENA MITTAL

DEPARTMENT OF PATHOLOGY
SANTOSH MEDICAL COLLEGE & HOSPITAL
GHAZIABAD, NCR DELHI

SANTOSH DEEMED TO BE UNIVERSITY

NO. 1, SANTOSH NAGAR,

GHAZIABAD-201009, NCR DELHI, INDIA

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Guide
Dr. Adreena Mittal
Professor and Head
Department of Pathology
Santosh Medical College & Hospital
Ghaziabad NCR, India

CERTIFICATE BY THE CO-GUIDE

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Co-Guide

Dr. Ashok Kumar
Professor & Head
Department of Medicine
Santosh Medical College & Hospital
Ghaziabad NCR, India

CERTIFICATE BY THE CO-GUIDE

This is to certify that the thesis titled **"EVALUATION OF PLATELET INDICES IN TYPE 2 DIABETES MELLITUS"** is a bonafide genuine research work carried out by **Dr. Geetanjali Yadav** in partial fulfilment of the requirements for award of the degree of M.D. in the speciality of Pathology.

Co-Guide

Dr. Mansi Jain
Assistant Professor
Department of Pathology
Santosh Medical College & Hospital
Ghaziabad NCR, India

CERTIFICATE BY THE HEAD OF THE DEPARTMENT

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PROF. (Dr.) Adreena Mittal
M.B.B.S., M.D.
Professor & Head
Department of Pathology
Santosh Medical College & Hospital
Ghaziabad, NCR, India

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Dr Alka Agrawal
Dean
Faculty of Medical Sciences
Santosh Medical College & Hospital
Santosh Deemed to be University
Ghaziabad, NCR, India

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ABERRATIONS

1. DM - Diabetes Mellitus
2. T2DM - Type 2 Diabetes Mellitus
3. MPV - Mean Platelet Volume
4. PDW - Platelet Distribution Width
5. P-LCR - Platelet Large Cell Ratio
6. HbA1c - Glycated Hemoglobin
7. BMI - Body Mass Index
8. SPSS - Statistical Package for the Social Sciences
9. CBC - Complete Blood Count
10. SD - Standard Deviation
11. OPD - Outpatient Department
12. NCD - Non-Communicable Diseases
13. WHO - World Health Organization
14. IDF - International Diabetes Federation
15. SDS - Sample Data Set

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Introduction

INTRODUCTION

Diabetes mellitus (DM) stands as one of the most ancient maladies documented in human history, tracing its origins back through millennia. Its prevalence has surged over time, evolving into a global pandemic with alarming rates of morbidity. Defined by the World Health Organization (WHO) as a multifaceted metabolic disorder, DM manifests through chronic hyperglycemia, disrupting the intricate balance of carbohydrate, fat, and protein metabolism due to deficiencies in insulin secretion, insulin action, or both.[1]

According to the International Diabetes Federation (IDF), the burden of DM weighed heavily in 2018, afflicting an estimated 425 million individuals worldwide, with projections ominously foreseeing an escalation to 642 million by 2040. WHO set ambitious targets in 2013, envisioning a 25% reduction in mortality from Non-Communicable Diseases (NCDs) by 2025. Similarly, the Sustainable Development Goals (SDGs) outlined a mandate for a one-third decrease in premature deaths attributed to NCDs, including diabetes, by 2030.[2,3]

The escalating prevalence of DM constitutes a burgeoning health crisis, intricately linked to an elevated risk of both microvascular and macrovascular complications. A predominant cause of vascular occlusive events stems from a cascade involving atherosclerotic plaque disruption, platelet aggregation, adhesion, and subsequent intravascular thrombosis. In diabetes, various systems crucial for maintaining vascular integrity and patency, such as platelet and endothelial function, coagulation, and fibrinolysis, become compromised. Consequently, the delicate balance of normal hemostasis tilts towards favoring thrombosis, heightening the susceptibility to cardiovascular and cerebrovascular occlusions.[4]

Platelet indices, including mean platelet volume (MPV), platelet distribution width (PDW), and platelet large cell ratio (P-LCR), serve as pivotal parameters in assessing thrombogenesis. MPV reflects alterations in platelet stimulation or production rates, while PDW signifies platelet heterogeneity, potentially arising from platelet aging or heterogeneous megakaryocyte demarcation. P-LCR quantifies larger platelets, offering valuable insights into thrombotic tendencies. Consequently, variations in MPV and PDW serve as surrogate markers for vascular complications in DM, heralding impending risks.[5,6]

These platelet parameters, being cost-effective and readily available, present themselves as invaluable tools for early detection and monitoring of DM complications. Thus, in light of their significance, this study aims to scrutinize and juxtapose platelet indices between healthy individuals and diabetic patients, shedding further light on their diagnostic and prognostic utility.

Diabetes mellitus (DM) stands as a global pandemic, posing significant challenges to healthcare systems worldwide. This condition represents the most prevalent group of metabolic disorders, characterized by persistent hyperglycemia. The ramifications extend far beyond mere elevated blood sugar levels, manifesting in secondary damage to multiple organ systems, notably the kidneys, eyes, peripheral nerves, and blood vessels. Within this complex web of pathophysiology, platelet activation emerges as a pivotal player, implicated in the development of vascular complications.

Recent research has spotlighted mean platelet volume (MPV) as a critical parameter in understanding the pathogenesis of diabetic vascular complications. Elevated MPV levels, particularly notable in individuals with poorly controlled diabetes, underscore a potential link between platelet dynamics and the progression of the disease. Platelet

volume serves as a surrogate marker for platelet function and activation status, offering insights into the underlying mechanisms driving altered platelet morphology and functionality.[7]

The concept is relatively straight”orwa’d yet profound: the higher the MPV, the larger and more youthful the platelets, correlating with an increased propensity for thrombotic events. This association underscores the intricate interplay between platelet biology and the hyperglycemic milieu characteristic of diabetes. Moreover, elevated MPV emerges not only as a marker of disease severity but also as a predictor of hyperglycemic complications, serving as a harbinger of adverse outcomes.

In clinical practice, MPV holds promise as a valuable diagnostic and prognostic tool. Its measurement through routine hematology analyzers offers a simple, cost-effective means of assessing platelet volume and function. By monitoring MPV levels, healthcare providers can glean insights into the presence and progression of vascular complications in diabetic patients, enabling timely intervention and management strategies.

Thus, amidst the complex landscape of diabetes mellitus and its associated complications, MPV emerges as a beacon of potential—a tangible parameter offering invaluable insights into the underlying pathophysiology and heralding new avenues for personalized patient care.

Diabetes mellitus (DM) stands as a persistent metabolic anomaly characterized by prolonged elevation of blood glucose levels. This condition can arise from a variety of factors, including compromised insulin secretion, resistance to insulin’s peripheral actions, or a combination of both. According to the International Diabetes Federation (IDF), the prevalence of DM among adults aged 20 to 79 years was estimated to be

approximately 415 million in 2015, indicative of its widespread impact on global health dynamics. Alarmingly, projections suggest that this figure will escalate by an additional 200 million individuals by the year 2040, underscoring the urgent need for comprehensive strategies to tackle this burgeoning health crisis.

The ramifications of chronic hyperglycemia, coupled with associated metabolic anomalies, extend across various organ systems, precipitating the onset of debilitating and potentially life-threatening complications. Among these, microvascular complications such as retinopathy, nephropathy, and neuropathy emerge as significant concerns, alongside macrovascular complications that confer a pronounced 2-fold to 4-fold elevation in the risk of cardiovascular diseases. This intricate interplay between hyperglycemia and systemic physiological dysregulation underscores the multifaceted nature of DM and emphasizes the imperative for targeted interventions aimed at mitigating its adverse sequelae.[8]

Within this comprehensive review, we endeavor to provide a holistic exploration of the pathogenesis, diagnostic modalities, clinical manifestations, and fundamental principles governing the management of diabetes mellitus. By elucidating these key facets, we aim to enhance understanding among clinicians, researchers, and stakeholders alike, thereby facilitating the development and implementation of effective strategies to combat the escalating burden of DM on a global scale.

Platelets, the smallest blood cells in the human body, typically measure around 2μm in diameter and are devoid of a nucleus. They boast an average lifespan of 7 to 10 days within the circulatory system.[9,10] The pivotal role of platelets in hemostasis was initially recognized over a century ago by the distinguished Italian pathologist Giulio Bizzozero. Subsequent to this landmark observation, substantial strides were made in

comprehending the intricacies of platelet function in hemostasis and thrombosis throughout the 20th century, primarily through the utilization of light microscopy techniques.[11] However, in recent times, the advent of advanced methodologies such as electron microscopy and immunofluorescence has ushered in a new era of scientific inquiry, allowing for significantly enhanced analysis of platelet ultrastructure and functionality. These cutting-edge techniques offer unprecedented insights into the intricate workings of platelets, further deepening our understanding of their physiological significance in maintaining vascular integrity and regulating hemostasis.

Aims

&

Objectives

AIMS AND OBJECTIVES

AIM: -

The proposed study entitled as **"EVALUATION OF PLATELET INDICES IN TYPE 2 DIABETES MELLITUS"** will be conducted to establish a relation between platelet indices and early diagnosis of complications in DM.

OBJECTIVE: -

This study will be conducted:

- To compare platelet indices in diabetic and non-diabetic patients.
- To compare platelet indices in diabetic patients who are under good glycaemic control and poor glycaemic control.
- To compare platelet indices with duration of diabetes.
- To compare platelet indices with BMI.

Review of Literature

REVIEW OF LITERATURE

Type 2 diabetes mellitus (T2DM) stands as a chronic condition, emerging as a formidable challenge within the realm of public health on a global scale. According to statistics provided by the International Diabetes Federation (IDF), an estimated 387 million individuals grappled with diabetes worldwide in 2014, with projections indicating a staggering increase to 592 million by the year 2035. Notably, China and India took the forefront in 2013, with 98.4 million and 65.1 million cases of diabetes, respectively, solidifying their positions as the countries with the highest prevalence rates.[12]

T2DM commands a significant portion, accounting for approximately 90% of all diabetes cases across the globe. It manifests in individuals with genetic predispositions, triggered by a cascade of environmental factors. Variables such as ethnic background, gender, and age play pivotal roles in determining one's susceptibility to developing T2DM. The onset of clinical disease is characterized by a cascade of physiological events, including reduced insulin secretion, impaired glucose utilization, and heightened glucose production, all culminating in hyperglycemia.[13]

Diabetes Mellitus, fundamentally, represents a state of metabolic dysregulation, with profound implications for various organ systems. Microvascular and macrovascular complications emerge as consequential outcomes, exerting a substantial burden on both affected individuals and the healthcare infrastructure. Thus, there arises an imperative to institute early detection measures, cost-effective in nature, aimed at mitigating and managing these complications effectively.

Given the trajectory of its prevalence and its intricate interplay with systemic health, it becomes increasingly evident that DM will emerge as a leading cause of morbidity and mortality in the foreseeable future. As such, proactive strategies for prevention, early intervention, and comprehensive management are paramount in curbing the impending healthcare crisis posed by T2DM.

EPIDEMIOLOGIC DETERMINANTS AND RISK FACTORS

OF TYPE 2 DM[12]

GENETIC FACTORS:

Genetic markers play a crucial role in various fields of study, offering insights into hereditary traits and potential health risks. One such area where genetic markers are extensively utilized is in understanding familial predispositions and hereditary conditions. Family history stands as a prominent genetic marker, providing invaluable information about the likelihood of certain diseases or conditions manifesting in individuals. By examining patterns of disease occurrence within families across generations, medical professionals can better assess risks and tailor preventive measures or treatment plans accordingly.

Moreover, the concept of “thrifty genes” adds another layer to our understanding of genetic markers. Originally proposed by geneticist James V. Neel in 1962, thrifty genes refer to genetic variants that may have provided adaptive advantages to our ancestors during times of food scarcity. These genes allowed for efficient storage of energy, enhancing survival chances in environments where food availability was unpredictable. However, in modern societies characterized by abundant food sources and sedentary

lifestyles, these thrifty genes can predispose individuals to conditions like obesity and metabolic disorders.

Understanding the interplay between genetic markers, family history, and thrifty genes is vital in contemporary healthcare and genetic research. By unraveling the genetic basis of various conditions and diseases, researchers can develop more targeted interventions and personalized treatment strategies. Furthermore, this knowledge empowers individuals to make informed decisions about their health and lifestyle choices, potentially mitigating genetic predispositions through proactive measures such as dietary modifications and regular exercise routines. Thus, genetic markers serve not only as tools for scientific inquiry but also as catalysts for promoting health and well-being in diverse populations.

DEMOGRAPHIC CHARACTERISTICS:

Gender, age (above 45 years), and ethnicity, encompassing diverse backgrounds such as Asian American, Latino, Native American, African American, and Pacific Islander, are crucial factors often considered in various studies and analyses. These demographics play significant roles in shaping societal dynamics, healthcare outcomes, and cultural perspectives. Understanding the nuances within these demographic categories is essential for conducting thorough research and implementing inclusive policies that address the needs and experiences of diverse populations. By acknowledging and appreciating the intersectionality of gender, age, and ethnicity, researchers and policymakers can develop more comprehensive approaches to promote equity and inclusivity across various domains.

BEHAVIORAL AND LIFESTYLE-RELATED RISKFACTORS:

Addressing the issue of obesity involves a multifaceted approach that encompasses various factors, including the duration and distribution of excess weight, levels of physical activity, dietary habits, stress management, and broader societal changes such as Westernization, urbanization, and modernization. Obesity, characterized by an excessive accumulation of body fat, is influenced by both genetic and environmental factors. While genetics play a role in predisposing individuals to obesity, environmental factors such as sedentary lifestyles and poor dietary choices significantly contribute to its prevalence. Prolonged periods of physical inactivity, whether due to desk-bound jobs, lack of access to recreational facilities, or reliance on motorized transportation, contribute to weight gain and obesity. Similarly, diets high in processed foods, refined sugars, and saturated fats promote weight gain and increase the risk of obesity-related health conditions such as cardiovascular disease and type 2 diabetes. Moreover, the pervasiveness of stress in modern life can lead to emotional eating and unhealthy coping mechanisms, further exacerbating the obesity epidemic. Furthermore, the phenomenon of Westernization, urbanization, and modernization has brought about changes in lifestyle and dietary patterns, with a shift towards calorie-dense, nutrient-poor foods and a decrease in physical activity levels. As societies become more urbanized and reliant on convenience foods, the prevalence of obesity tends to rise. Addressing these interconnected factors requires comprehensive strategies that promote healthy behaviors, encourage physical activity, improve access to nutritious foods, and mitigate the impact of stressors in daily life. By addressing these root causes of obesity, communities can work towards preventing and managing this complex health issue effectively.

METABOLIC DETERMINANTS AND INTERMEDIATE-RISK

CATEGORIES OF TYPE2 DIABETES[12]

Reduced glucose tolerance, insulin resistance, factors related to pregnancy, such as parity and gestational diabetes, as well as the potential risk of diabetes in offspring born to mothers with a history of gestational diabetes, are all significant considerations in the realm of maternal health. Additionally, the intrauterine environment plays a crucial role, as malnutrition or overnutrition during pregnancy can impact the long-term metabolic health of the offspring. These factors collectively underscore the intricate interplay between maternal health, gestational factors, and the risk of metabolic disorders in both the mother and her offspring. Therefore, understanding and addressing these multifaceted determinants are essential for promoting optimal maternal and child health outcomes.

ETIOLOGIC CLASSIFICATION OF DIABETES

MELLITUS[7]

Type 1 diabetes, characterized by absolute insulin deficiency due to the destruction of beta cells, can manifest through two primary mechanisms: immune-mediated and idiopathic. In contrast, Type 2 diabetes encompasses a spectrum wherein individuals may exhibit either predominant insulin resistance coupled with relative insulin deficiency or a predominant insulin secretory defect alongside insulin resistance.

Further categorization reveals various specific types of diabetes, including those arising from genetic defects affecting beta cell development or function. Noteworthy mutations involve genes such as Hepatocyte Nuclear Transcription Factor (HNF) 4α (MODY 1), Glucokinase (MODY 2), HNF-1α (MODY 3), Insulin Promoter Factor-1 (IPF-1)

(MODY 4), HNF-1β (MODY 5), NeuroD1 (MODY 6), as well as mitochondrial DNA and subunits of ATP-sensitive potassium channels. Additionally, defects in insulin action can result from conditions like Type A insulin resistance, Leprechaunism, Rabson-Mendenhall syndrome, and various lipodystrophy syndromes.

Diabetes can also be associated with diseases affecting the exocrine pancreas, including pancreatitis, pancreatectomy, neoplasia, fibrocalculous pancreatopathy, cystic fibrosis, hemochromatosis, and mutations in carboxyl ester lipase. Endocrinopathies such as acromegaly, Cushing's syndrome, glucagonoma, pheochromocytoma, somatostatinoma, hyperthyroidism, and aldosteronoma are also implicated.

Furthermore, drug or chemical-induced diabetes may occur due to factors like glucocorticoids, vacor, pentamidine, nicotinic acid, diazoxide, β-adrenergic agonists, thiazides, calcineurin and mTOR inhibitors, hydantoins, asparaginase, α-interferon, protease inhibitors, and certain antipsychotics. Infections such as congenital rubella, cytomegalovirus, and coxsackievirus can also contribute to the development of diabetes.

Rare forms of immune-mediated diabetes, such as "stiff-person" syndrome and anti-insulin receptor antibody-related diabetes, underscore the diverse etiological spectrum. Additionally, genetic syndromes like Wolfram's syndrome, Down's syndrome, Klinefelter's syndrome, Turner's syndrome, Friedreich's ataxia, Huntington's chorea, Laurence-Moon-Biedl syndrome, myotonic dystrophy, porphyria, and Prader-Willi syndrome may exhibit associations with diabetes.

Lastly, gestational diabetes mellitus presents another facet of diabetes, specifically occurring during pregnancy. This comprehensive understanding of the various types and etiological factors underscores the complexity of diabetes mellitus.

CRITERIA FOR THE DIAGNOSIS OF DIABETES

MELLITUS[6]

Symptoms indicating the presence of diabetes often manifest with a random blood glucose concentration of equal to or greater than 200 mg/dL. Additionally, a fasting plasma glucose level exceeding 126 mg/dL or a haemoglobin A1c (HbA1c) level at or above 6.5% are indicative of the condition. Another diagnostic criterion involves a 2-hour plasma glucose measurement during an oral glucose tolerance test that equals or surpasses 200 mg/dL. These parameters serve as crucial indicators for healthcare professionals to identify and diagnose diabetes in individuals. When these thresholds are met or exceeded, it necessitates further evaluation and management to mitigate the risks associated with diabetes and its potential complications.

SCREENING FOR TYPE 2 DIABETES MELLITUS – MAJOR

RECOMMENDATIONS[6]

Screening for the early detection of Type 2 Diabetes Mellitus (T2DM) and the assessment of future risk for diabetes is a critical consideration, particularly among asymptomatic adults who fall within the overweight or obese BMI range (BMI $\geq$ 25 kg/m^2 or $\geq$ 23 kg/m^2 in Asian Americans). This demographic, when coupled with one or more additional risk factors for diabetes, warrants particular attention.

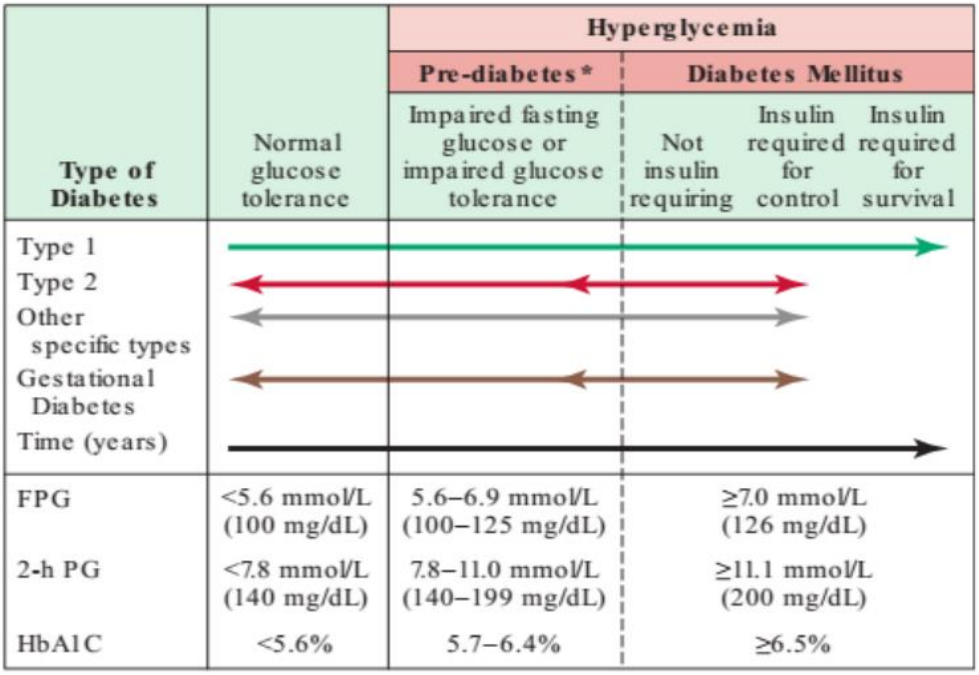
Initiating testing protocols between the ages of 30 to 45 years is advisable for individuals without apparent risk factors for T2DM. However, it’s essential to underscore the importance of repeated testing at intervals of 3 to 5 years, particularly if initial test results return within the normal range. This periodic reevaluation is vital for ensuring ongoing vigilance and early detection.

Various testing methodologies are deemed appropriate for this purpose, including but not limited to Hemoglobin A1c (HbA1c), Fasting Plasma Glucose (FPG), and the 2-hour 75-gram Oral Glucose Tolerance Test (OGTT). Each of these methods offers distinct advantages in different clinical scenarios, thus providing flexibility in the screening process.

Moreover, beyond the primary focus on diabetes, it's imperative to recognize and address other cardiovascular disease (CVD) risk factors that may coincide with an increased risk of developing diabetes in the future. Managing these comorbidities effectively can contribute significantly to overall health outcomes and mitigate the progression of both diabetes and associated cardiovascular complications.

In summary, a comprehensive approach to screening for T2DM and assessing future diabetes risk involves targeted testing protocols tailored to individual risk profiles, periodic reevaluation, and a broader consideration of concurrent CVD risk factors. By integrating these strategies into clinical practice, healthcare providers can effectively identify individuals at risk, initiate timely interventions, and ultimately improve long-term health outcomes.

SPECTRUM OF GLUCOSE HOMEOSTASIS AND DM



American Diabetes Association, 2014.

PATHOGENESIS OF TYPE 2 DIABETES MELLITUS[6]

The interplay between specific genetic anomalies and detrimental environmental influences can lead to the onset and progression of type 2 diabetes. This complex interaction involves a multitude of genetic factors, each potentially predisposing an individual to heightened susceptibility to the disease when coupled with adverse environmental conditions. Understanding the intricate dynamics between genetic predispositions and environmental stressors is paramount in elucidating the underlying mechanisms driving the pathogenesis of type 2 diabetes.

Type 2 diabetes, characterized by insulin resistance and impaired insulin secretion, is influenced by a diverse array of genetic variations. These genetic aberrations can affect various aspects of glucose metabolism, insulin signaling pathways, and pancreatic

function. However, the manifestation of type 2 diabetes often requires the confluence of genetic predisposition with environmental triggers.

Environmental factors play a crucial role in modulating gene expression and influencing disease susceptibility. Lifestyle factors such as diet, physical activity, and stress levels can exert profound effects on metabolic health and contribute to the development of insulin resistance and beta-cell dysfunction. Moreover, environmental toxins, pollutants, and socio-economic factors can exacerbate metabolic disturbances, further exacerbating the risk of type 2 diabetes.

The Interaction between genetic predisposition and environmental factors Is not deterministic but rather probabilistic, with varying degrees of susceptibility among individuals. Certain genetic variants may confer increased susceptibility to environmental insults, while others may exert protective effects. Additionally, the timing and duration of exposure to environmental stressors can profoundly impact disease risk, highlighting the importance of considering temporal dynamics in disease etiology.

Emerging research endeavors to unravel the intricate interplay between genetics and environment in the context of type 2 diabetes. Genome-wide association studies (GWAS) have identified numerous genetic loci associated with type 2 diabetes risk, shedding light on the genetic architecture of the disease. However, understanding how these genetic variants interact with environmental factors remains a challenging yet critical endeavor.

Integrating genetic and environmental data through interdisciplinary approaches such as systems biology and precision medicine holds promise for elucidating the complex etiology of type 2 diabetes. By delineating the interactive networks underlying disease

susceptibility, researchers aim to identify novel therapeutic targets and develop personalized interventions tailored to individual genetic and environmental profiles.

In conclusion, the development of type 2 diabetes is not solely determined by genetic predisposition but is intricately influenced by interactions with adverse environmental factors. Deciphering the complex interplay between genetics and environment is essential for advancing our understanding of disease pathogenesis and developing effective strategies for prevention and treatment.

GENETIC FACTORS

There exists a significant concordance rate ranging between 70% to 90% for type 2 diabetes mellitus (DM) among identical twins, indicating a strong genetic predisposition. Moreover, individuals with a parent affected by type 2 DM are at an increased risk themselves. Notably, if both parents are afflicted with type 2 DM, the risk escalates to approximately 40%. Intriguingly, the prenatal environment also exerts a substantial influence on disease development. Both high and low birth weights have been associated with an elevated risk of type 2 DM later in life.Despite extensive research, the precise genetic factors contributing to type 2 DM susceptibility remain incompletely understood. Among the identified genetic variants, the transcription factor 7-like 2 (TCF7L2) gene variant stands out prominently. This variant has demonstrated associations with type 2 DM across diverse populations and with impaired glucose tolerance (IGT) in high-risk diabetes populations. Additionally, variations in genes encoding the inward rectifying potassium channel, peroxisome proliferator–activated receptor γ (PPARγ), zinc transporter, insulin receptor substrate (IRS), and calpain 10 have been linked to type 2 DM susceptibility through genetic polymorphisms.

Despite these associations, the exact mechanisms through which these genetic loci contribute to increased susceptibility to type 2 DM remain elusive. However, it is widely believed that these genetic variations may influence islet cell function, insulin secretion, or development, thereby altering glucose metabolism and predisposing individuals to type 2 DM. Further research is necessary to elucidate the intricate interplay between genetic predisposition and environmental factors in the pathogenesis of type 2 DM.

ENVIRONMENTAL FACTORS

Commonly acknowledged environmental factors contributing to the onset of type 2 diabetes include sedentary lifestyle and excessive calorie consumption. These factors can act independently to trigger the condition in individuals with a genetic predisposition or can lead to its development indirectly by causing obesity and metabolic syndrome. Central obesity, indicated by a high waist-to-hip ratio, is prevalent in a significant majority of type 2 diabetes cases, with approximately 80% of affected individuals being obese. Metabolic syndrome manifests when type 2 diabetes and obesity coexist alongside other abnormalities such as elevated triglyceride levels, low HDL cholesterol levels, and hypertension. It’s estimated that around 25% to 30% of the Indian population grapples with metabolic syndrome.

Type 2 diabetes is typified by insulin resistance, impaired insulin secretion, heightened glucose production by the liver, and aberrant fat metabolism. In the early stages of the disease, glucose tolerance remains relatively normal despite the presence of insulin resistance, as pancreatic beta cells endeavor to compensate by augmenting insulin secretion. However, as compensatory hyperinsulinemia and insulin resistance progress, some individuals’ pancreatic islets become incapable of sustaining the

hyperinsulinemic state. Consequently, these individuals experience elevated postprandial glucose levels, indicative of impaired glucose tolerance. Further deterioration in insulin secretion and an increase in hepatic glucose production ultimately lead to overt diabetes characterized by fasting hyperglycemia. Eventually, beta cell failure sets in as the disease progresses.

METABOLIC ABNORMALITIES

Abnormal muscle and fat metabolism:

The diminished effectiveness of insulin on target tissues, notably fat, liver, and muscle, characterized by insulin resistance, stands as a prominent hallmark of type 2 diabetes mellitus (DM). The interplay between obesity and genetic predisposition fosters the onset of insulin resistance, culminating in compromised glucose utilization by insulin-sensitive tissues and heightened hepatic glucose output. Consequently, these dual effects precipitate hyperglycemia. Predominantly, elevated fasting plasma glucose (FPG) levels stem from heightened hepatic glucose output, whereas diminished peripheral glucose utilization underlies postprandial hyperglycemia. Notably, skeletal muscle exhibits a greater impairment in glycogen formation (nonoxidative glucose usage) compared to glycolysis (oxidative glucose metabolism) in type 2 DM, with glucose metabolism remaining largely unaltered in insulin-independent tissues.

Insulin-mediated phosphorylation/dephosphorylation mechanisms emerge as pivotal players in insulin resistance. Intriguingly, lipid accumulation within skeletal myocytes ensues, potentially impairing mitochondrial oxidative phosphorylation and diminishing insulin-stimulated ATP production therein. The accrual of reactive oxygen species, such as lipid peroxides, results from impaired fatty acid oxidation and intracellular lipid buildup within skeletal myocytes.

Obesity, particularly in central or visceral regions, accompanying type 2 DM, is deemed integral to the pathogenic cascade. Augmented adipocyte mass leads to elevated circulating levels of free fatty acids and other adipocyte-derived products. Noteworthy among these are nonesterified free fatty acids, leptin, NF-α, retinol-binding protein 4, resistin, IL-6, and adiponectin. Free fatty acids detrimentally impact glucose utilization in skeletal muscle, impair beta cell function, and bolster hepatic glucose production. Conversely, the diminished production of adiponectin, an insulin-sensitizing peptide by adipocytes, in obesity potentially exacerbates hepatic insulin resistance. Furthermore, adipokines and adipocyte-derived products may incite an inflammatory milieu.

Impaired insulin secretion

Initially, in response to insulin resistance in type 2 diabetes mellitus (DM), there is an upsurge in insulin secretion aimed at preserving normal glucose tolerance. This surge is crucial to compensate for the body's reduced sensitivity to insulin. Consequently, the defect in insulin secretion during the early stages of type 2 DM is relatively mild, primarily affecting glucose-stimulated insulin secretion. This phase often sees a significant reduction in the first secretory phase, indicative of the body's attempt to regulate blood sugar levels.

As type 2 DM progresses over time, there is a notable decline in beta cell mass, diminishing by approximately 50% in individuals with longstanding conditions. One of the key pathological features observed in the islets of these individuals is the deposition of amyloid fibrils, primarily composed of amylin or Islet amyloid polypeptide, which are co-secreted by beta cells. This deposition is linked to chronic hyperglycemia, forming a vicious cycle where elevated blood sugar levels lead to further deterioration in islet function, a phenomenon often termed as "glucose toxicity." Paradoxically,

despite the increased insulin secretion, the hyperglycemia worsens, exacerbating the condition.

However, there is hope for ameliorating islet function and consequently glycemic control. Improvements in glycemic control have been observed to coincide with enhanced islet function. This suggests a potential avenue for therapeutic intervention wherein targeting glycemic levels may lead to a positive feedback loop of improved insulin secretion and better glucose regulation.

Moreover, dietary factors also play a significant role. Increased consumption of dietary fats and elevated levels of free fatty acids can lead to “lipotoxicity,” further impairing islet function. This highlights the importance of dietary management in the treatment of type 2 DM, not only for controlling blood sugar levels but also for preserving pancreatic health and insulin secretion.

Additionally, reduced action of glucagon-like peptide-1 (GLP-1) is implicated in the decline of insulin secretion. GLP-1 is an incretin hormone known for its role in stimulating insulin secretion in response to elevated blood sugar levels. Therefore, therapies aimed at enhancing GLP-1 activity may hold promise in addressing the impaired insulin secretion characteristic of type 2 DM.

In conclusion, the intricate interplay between insulin resistance, beta cell dysfunction, and various pathological factors underscores the complexity of type 2 DM. Addressing these factors, whether through pharmacological interventions, dietary modifications, or lifestyle changes, holds the key to preserving islet function and achieving optimal glycemic control in individuals with type 2 DM.

Increased hepatic glucose and lipid production:

In the intricate metabolic landscape of the body, the liver plays a pivotal role in maintaining glucose homeostasis, primarily regulated by insulin. However, when insulin resistance sets in, this delicate balance is disrupted, heralding a cascade of metabolic disturbances. Insulin resistance in the liver signifies a crucial failure wherein hyperinsulinemia, the elevated presence of insulin, loses its efficacy in curbing gluconeogenesis. Consequently, this failure manifests as diminished glycogen storage during the postprandial phase and results in fasting hyperglycemia, a hallmark of type 2 diabetes mellitus (DM).

Moreover, the ramifications of insulin resistance extend beyond glycemic control, infiltrating adipose tissue with profound implications. Within adipose tissue, insulin resistance triggers a surge in lipolysis, the breakdown of fats, instigating a heightened flux of free fatty acids emanating from adipocytes. These liberated fatty acids embark on a journey to hepatocytes, liver cells, where they serve as substrates for enhanced lipid synthesis, encompassing triglycerides and very-low-density lipoprotein (VLDL). Consequently, this dysregulated lipid metabolism precipitates lipid accumulation within hepatocytes, a phenomenon known as hepatic steatosis or nonalcoholic fatty liver disease (NAFLD). The perturbation in liver function stemming from NAFLD further exacerbates the dyslipidemia observed in individuals afflicted with type 2 DM.

Thus, the intricate interplay of insulin resistance within both hepatic and adipose tissue underscores the multifaceted nature of metabolic dysregulation in type 2 DM. Beyond the confines of glycemic control, these disruptions echo across various metabolic pathways, engendering a milieu ripe for the emergence of comorbidities such as NAFLD and dyslipidemia.

INSULIN RESISTANCE SYNDROMES[13]

"This encompasses a range of metabolic abnormalities, including insulin resistance, dyslipidemia (lowered HDL and increased triglycerides), high blood pressure, central or abdominal obesity, impaired glucose tolerance (IGT) / impaired fasting glucose (IFG), or type 2 diabetes mellitus, and accelerated development of cardiovascular disease. In adults, there are two distinct severe insulin resistance syndromes:

1. Type A: This primarily affects young females and is marked by significant hyperinsulinemia, manifestations of hyperandrogenism, and obesity.

2. Type B: This predominantly affects middle-aged women, who exhibit autoantibodies targeting the insulin receptor. These autoantibodies may either stimulate the insulin receptor, resulting in intermittent hypoglycemia, or inhibit insulin binding. It is characterized by features of hyperandrogenism, severe hyperinsulinemia, and autoimmune disorders."

CHRONIC COMPLICATIONS OF HYPERGLYCAEMIA

Complications in diabetes are categorized into two main types:

(11)Microvascular Complications: These include diabetic retinopathy, neuropathy, and nephropathy.

(b) Macrovascular Complications: These comprise coronary artery disease (CAD), cerebrovascular stroke, and peripheral artery disease (PAD).

Chronic hyperglycemia is a significant factor in the development of these complications, although some individuals may also have a genetic predisposition to certain complications. Numerous large randomized clinical trials involving individuals with

type-1 or type-2 diabetes have unequivocally shown that reducing chronic hyperglycemia can delay or even prevent the onset of nephropathy, neuropathy, and retinopathy.

PATHOGENESIS OF MICROVASCULAR DISEASES[14]

AGES THEORY: Elevated levels of glucose within cells lead to the interaction of glucose molecules with amino acid groups on proteins, resulting in nonenzymatic glycosylation of both intra- and extracellular proteins. This process culminates in the formation of advanced glycosylation end products (AGEs). Initially, non-enzymatic glycation products are reversible; however, sustained hyperglycemia leads to the formation of poorly reversible intermediate products and ultimately irreversible AGEs. Serum levels of AGEs correlate with the degree of hyperglycemia and accumulate as glomerular filtration rate declines. AGEs contribute to various pathological processes such as crosslinking of proteins (e.g., collagen), promotion of glomerular dysfunction, acceleration of atherosclerosis, induction of endothelial dysfunction, reduction in nitric oxide synthesis, and alteration of the composition and structure of the extracellular matrix. Moreover, AGEs bind to receptors on mesangial cells, leading to increased expression of transforming growth factor-β (TGF-β) and synthesis of the extracellular matrix.

SORBITOL PATHWAY (POLYOL PATHWAY): [15]When cellular glucose levels exceed normal limits, excess glucose is converted to sorbitol by the enzyme aldose reductase. Elevated sorbitol concentration disrupts cellular redox potential, generates reactive oxygen species, increases cellular osmolality, and promotes AGEs formation, thereby contributing to cellular dysfunction. Pathological conditions such as retinopathy, cataract formation, and neuropathy have been associated with this pathway.

Inhibitors of aldose reductase, such as epalrestat and fidarestat, are being explored for therapeutic purposes.

PROTEIN KINASE C PATHWAY: Hyperglycemia leads to increased diacylglycerol formation, subsequently activating protein kinase C (PKC). PKC, a family of serine/threonine kinases, alters the transcription of genes encoding various proteins involved in vascular functions, including type IV collagen, fibronectin, and extracellular matrix proteins. PKC also mediates signaling pathways involving angiotensin-II, TGF-β1, and vascular endothelial growth factor (VEGF), and modulates mitogen-activated protein kinase (MAPK), thereby contributing to sclerosis and other vascular complications.

HEXOSAMINE PATHWAY: The hexosamine pathway generates fructose-6-phosphate, which serves as a substrate for O-linked glycosylation and proteoglycan production. Hyperglycemia increases flux through this pathway, leading to alterations in protein function through glycosylation, such as endothelial nitric oxide synthase, and changes in gene expression of proteins like plasminogen activator inhibitor-1 (PAI-1) and transforming growth factor β (TGF-β). Growth factors play a significant role in diabetic complications, with pathways such as VEGF-A and TGF-β implicated in retinopathy and nephropathy.

RENIN-ANGIOTENSIN SYSTEM:[16] Abnormal activation of the renin-angiotensin system (RAS) occurs in diabetic nephropathy and retinopathy. Angiotensin-II binds to receptors in renal and retinal cells, leading to matrix deposition and impairment of glomerular and retinal structures via TGF-β1. Additionally, angiotensin-II stimulates VEGF production, exacerbating microvascular complications.

Clinical trials such as the Diabetes Control and Complications Trial (DCCT), the United Kingdom Prospective Diabetes Study (UKPDS), and trials like ACCORD-Eye and ADVANCE have demonstrated the importance of glycemic control in reducing the risk of microvascular complications in diabetes, including nephropathy, retinopathy, and neuropathy. These studies underscore the significance of not only glycemic control but also blood pressure management in mitigating vascular complications associated with diabetes.

OTHER RISK FACTORS

Hypertension leads to endothelial dysfunction, reduced availability of nitric oxide (NO), renal vasoconstriction, decreased glomerular filtration, impairment in tubuloglomerular feedback, reduced medullary flow, and worsened pressure natriuresis, ultimately resulting in progressive proteinuria. This cascade of events elevates intraglomerular pressure, initiating changes in the extracellular matrix. Consequently, hypertension significantly contributes to both macroangiopathy and microangiopathy in individuals with diabetes. Tight control of blood pressure through the use of angiotensin receptor blockers (ARBs) or ACE inhibitors (ACE-I) not only reduces intraglomerular pressure but also attenuates the renin-angiotensin system (RAS) activation, thereby lowering the incidence of nephropathy.[17]

Dyslipidemia is associated with increased urinary albumin excretion and endothelial damage due to oxidative stress in diabetic patients. Large-scale trials such as the Collaborative Atorvastatin Diabetes Study (CARDS) and the Fenofibrate Intervention in Event Lowering in Diabetes (FIELD) have demonstrated improvements in retinopathy and maculopathy with the treatment of dyslipidemia using atorvastatin and fenofibrate, respectively.

Obesity triggers the secretion of mediators such as non-esterified fatty acids (NEFAs), leptin, tumor necrosis factor-alpha (TNF-α), and adiponectin from adipocytes. These mediators directly influence microvascular alterations, endothelial function, NO production, and inflammation, thereby contributing to the development of microangiopathy.

Smoking induces oxidative stress, endothelial damage, and vasoconstriction, exacerbating microangiopathy. Diets high in trans and saturated fats also promote oxidative stress. Clinical studies have consistently shown that interventions targeting hyperglycemia, hypertension, dyslipidemia, obesity, smoking, and dietary habits, along with lifestyle modifications, yield significant benefits in the management of microangiopathic diseases.

DIABETIC KIDNEY DISEASE (DKD)

Excessive urinary excretion of albumin (UAE) followed by a decline in kidney function is a characteristic feature of DKD. The hallmark of DKD is proteinuria. The classical definition of DKD involves the presence of persistent albuminuria (≥300 mg/24 hours or ≥200 μg/min) or proteinuria ≥0.5 gm/24 hours, along with one of the following additional criteria: absence of evidence (clinical or laboratory) of other kidney and renal tract diseases and the presence of diabetic retinopathy. In type 2 diabetes, microalbuminuria, persistent albuminuria in the range of 30 to 299 mg/24 hours, has been linked to the incidence of nephropathy and cardiovascular disease (CVD) risk. In type 1 diabetes, it represents the earliest stage of diabetic nephropathy (DN).[18]

Pathogenesis of DKD involves increased glomerular filtration, inadequate tubular absorption, and increased tubular secretion, with the glomerular mechanism being dominant in the development of proteinuria.

For microalbuminuria (MA) screening, measurement of the albumin-to-creatinine ratio in an early morning or random spot collection (preferred method) may be employed. Over a 3 to 6-month period, two out of three collected specimens should show abnormal results. In all adults with diabetes, serum creatinine should be measured at least annually, regardless of UAE. Estimated glomerular filtration rate (eGFR) can then be determined using the modifications of diet in renal disease (MDRD) study equation. Chronic kidney disease (CKD) can be graded into five stages based on the GFR.

MANAGEMENT OF DIABETIC KIDNEY DISEASE

The multifaceted approach to managing DKD is widely acknowledged as the optimal strategy. The objective is to impede the progression of DKD and mitigate cardiovascular risks and mortality. Elevated blood glucose levels constitute a significant risk factor for microalbuminuria development. Studies indicate that reducing hemoglobin A1c by 1% can result in a notable 37% decline in microvascular complications.

Arterial hypertension stands out as a prominent contributor to DKD development and advancement. Analysis from the UK Prospective Diabetes Study (UKPDS) reveals a 13% decrease in microvascular complications risk with every 10 mm Hg reduction in systolic blood pressure (BP). Individuals maintaining systolic BP levels below 120 mm Hg exhibit the lowest complication risks. Initial treatment with ARBs and ACE inhibitors, alongside a diuretic, is recommended due to their established renoprotective effects. Even normotensive individuals could benefit from these medications to prevent

microalbuminuria development. Furthermore, ACE inhibitors and ARBs not only reduce the risk of microalbuminuria and macroalbuminuria but also contribute to fewer cardiovascular events.

Dietary protein restriction has demonstrated efficacy in decelerating renal function decline and reducing albuminuria. However, the impact of dyslipidemia treatment on DKD prevention or progression remains uncertain. Nevertheless, for diabetic patients, maintaining low-density lipoprotein (LDL) levels below 100 mg/dL and preferably below 70 mg/dL in the presence of cardiovascular disease is advised.

In cases of advanced renal disease among diabetic patients, renal replacement therapy may be necessary to alleviate renal failure symptoms and restore bodily homeostasis.

DIABETIC RETINOPATHY (DR)

DR, a retinal microvasculopathy, results from prolonged hyperglycemia. Its prevalence increases with prolonged diabetes duration, with nearly all type 1 and 60% of type 2 DM patients developing retinopathy after about 20 years. In the Indian subcontinent, DR prevalence ranges from 12% to 37% among type 2 DM patients. Key risk factors for DR onset and progression include diabetes duration, glycemic control, hypertension, and hyperlipidemia.

AETIOPATHOGENESIS

Hyperglycemia-induced vascular damage initiates DR. Early histological lesions include thickening of retinal capillary basement membrane and pericyte loss. Various biochemical, endocrine, and hemodynamic factors contribute to these changes, ultimately leading to retinal capillary incompetence or closure.

CLINICAL COURSE OF DIABETIC RETINOPATHY

DR is often asymptomatic initially. Hence, annual dilated fundus examination is recommended for all type 1 DM patients until signs of retinopathy emerge. Among type 2 DM patients, fundus examination should occur at diagnosis due to unknown disease onset and duration. Subsequent examination frequency depends on DR severity.

TREATMENT

In managing diabetic retinopathy (DR), a comprehensive approach is essential, similar to the management strategy for diabetic nephropathy. Key treatment objectives involve achieving optimal control over hyperglycemia, HbA1c levels, dyslipidemia, hypertension, nephropathy, and anemia. For diabetic macular edema (DME), treatment typically involves localized interventions such as laser photocoagulation alongside systemic management targeting risk factors. Studies like the UKPDS have shown that even a modest 1% reduction in HbA1c levels can significantly decrease the risk of microvascular complications, including DR, by up to 37%.

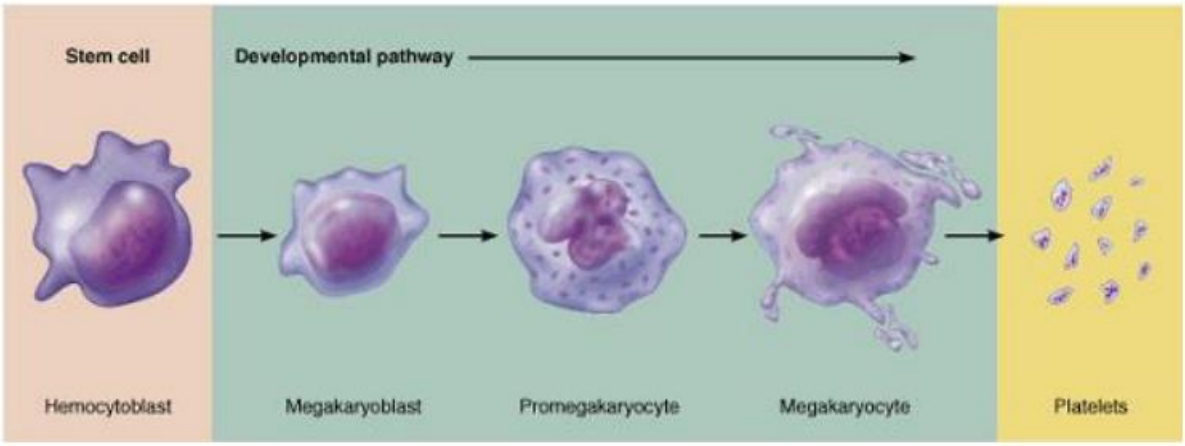
Regarding prognosis and prevention, early detection, patient education, and ongoing research play pivotal roles in mitigating visual impairment and preventing blindness resulting from DR. Direct ophthalmoscopy stands as the primary screening method for DR, aiding in the timely identification of patients requiring urgent intervention such as laser photocoagulation.

PLATELETS

Platelets are small, anucleate cell fragments that circulate in the bloodstream and play a vital role in regulating hemostasis and maintaining vascular integrity. They are integral to the process of chronic inflammation, which is often associated with various

disease pathologies. Platelets typically remain inactive until there is damage to a blood vessel, at which point they become activated. However, their function extends beyond hemostasis and includes monitoring the body's homeostasis through their sensitivity to various disease states. Additionally, platelets serve as significant inflammatory markers due to their interactions with leukocytes and endothelial cells.

Developmental pathway of platelets



Megakaryocytes located within the bone marrow are responsible for the production of platelets. These megakaryocytes, characterized by their large size and multinucleated structure, undergo a process wherein fragments break off from their edges, forming platelets. Each megakaryocyte can produce between 5000 to 10000 platelets.

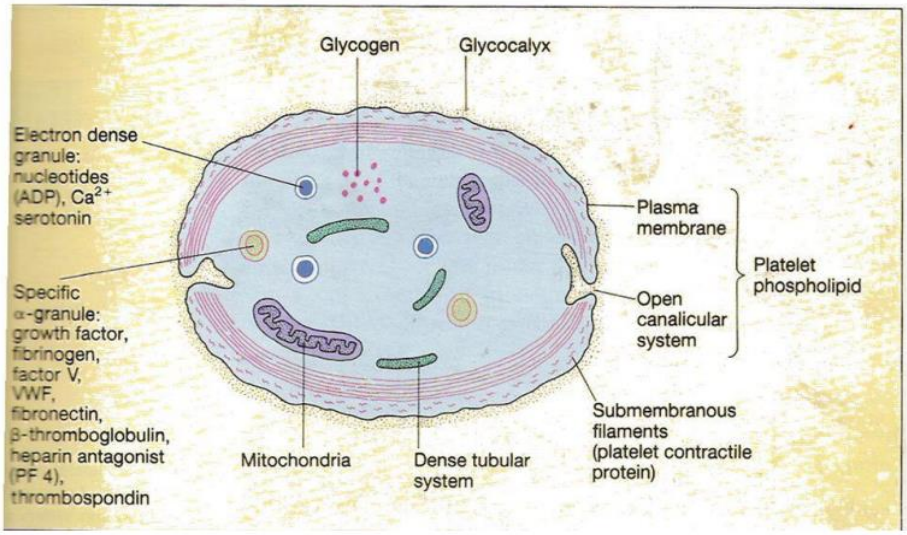
Platelets, also known as thrombocytes, are small cell fragments with a diameter ranging from 2 to 3 micrometers. They are present in the blood at a normal count of 150,000 to 400,000 per microliter, with approximately one-third of them stored in the spleen. The average lifespan of platelets ranges from 5 to 9 days, and an adult typically generates around 1011 platelets daily.

Platelets exhibit a unique ultrastructure, lacking a nucleus but containing distinct mitochondria. Their plasma membrane is composed of a phospholipid bilayer housing various surface receptors and lipid rafts such as CD9, CD36, CD63, IIbIIIa, GPCR, and GLUT-3, which play crucial roles in intracellular trafficking and signaling. Notably, GPCR is involved in the secretion of ADP from dense granules. Phospholipids like phosphatidylinositol and phosphatidylserine asymmetrically arranged in the inner layer of the plasma membrane contribute to surface stability during non-procoagulant states.

Platelets possess an open canalicular system (OCS), facilitating the release of granule contents and the entry of external elements. Additionally, the platelet cytoskeleton comprises spectrin-based membrane skeleton, marginal microtubule coil, and actin cytoskeleton, which collectively maintain its discoid shape and protect it from shear forces in the bloodstream.

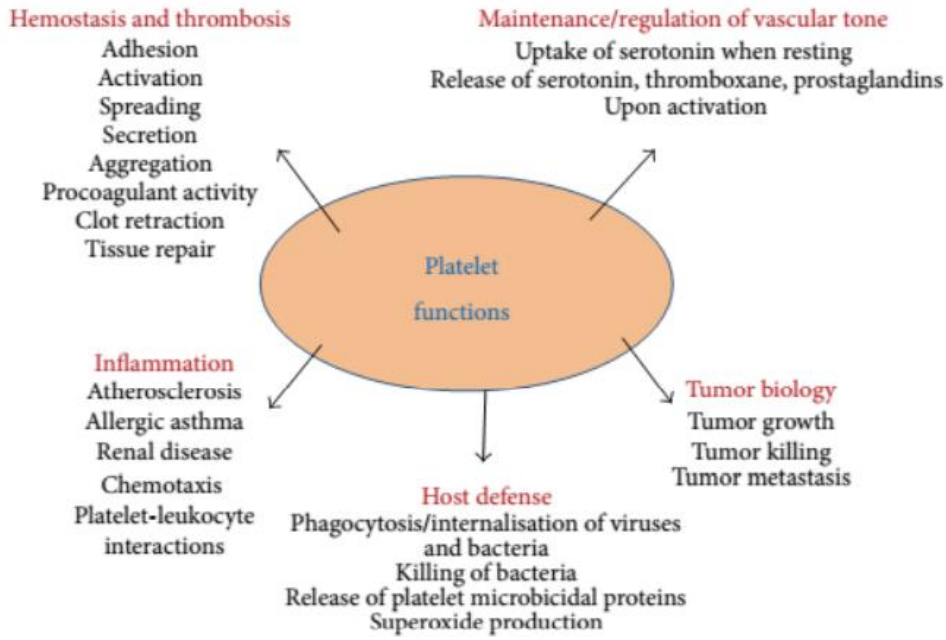
Two main types of granules are found within platelets: alpha and dense granules. Alpha granules contain platelet-specific proteins like PF-4, thromboglobulin, PDGF, thrombospondin, and plasma protein homologs such as fibrinogen, fibronectin, albumin, GPIIbIIIa, vWf, and P-selectin (CD62P), contributing to coagulation initiation and cell recruitment during inflammation. Dense granules store molecules like catecholamines, calcium, serotonin, ADP, and ATP, which are released upon platelet activation, with ADP acting as a weak platelet agonist, inducing shape change, granule release, and aggregation.

Platelets structure and function:


Glycogen
Glycocalyx
Electron dense granule: nucleotides (ADP), Ca^{2+} serotonin
Plasma membrane
Platelet phospholipid
Specific α-granule: growth factor, fibrinogen, factor V, VWF, fibronectin, β-thromboglobulin, heparin antagonist (PF 4), thrombospondin
Open canalicular system
Submembranous filaments (platelet contractile protein)
Mitochondria
Dense tubular system

PLATELET FUNCTIONS

Platelets play crucial roles in various pathophysiological processes. These include functions such as haemostasis and thrombosis, inflammation regulation, maintenance of vascular tone, participation in host defense mechanisms, and involvement in tumour biology.



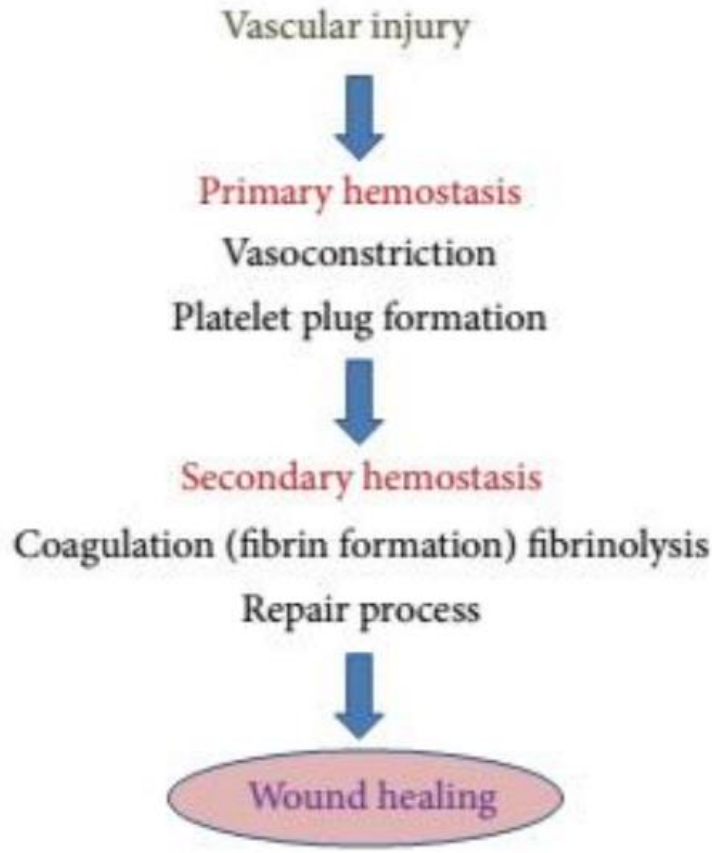
HEMOSTASIS AND THROMBOSIS:

The formation of a hemostatic plug is a complex process involving several key factors. Initially, adhesion to the damaged blood vessel lining, facilitated by calcium ions and ADP, promotes platelet aggregation, resulting in the formation of micro thrombi. These micro thrombi may enlarge, partially obstructing the vessel. At first, this aggregation is reversible but later becomes irreversible. Platelet discharge, leukocyte adherence, and fibrin deposition further contribute to plug formation.

Platelet adherence to collagen in damaged vessel walls triggers the release of ATP, which is converted to ADP by ATPase. Released ADP promotes further platelet aggregation, culminating in the formation of a platelet plug. Thrombin formation is initiated by tissue factor and phospholipids released from damaged vessels and platelets, respectively. A firm clot eventually seals the vessel permanently.

Following initial dilatation, damaged vessels undergo constriction for approximately 20 minutes, with serotonin (5-HT) playing a crucial role in vasoconstriction. Prostaglandins (PG) also participate in platelet aggregation. Phospholipase releases arachidonic acid from platelet cell membranes, which is rapidly oxidized by cyclo-oxygenase into PGG2 and PGH2. PGG2 is further converted to thromboxane A2 (TX A2) within platelets, a potent platelet aggregator and arterial muscle constrictor. Conversely, PGG2 and PGH2 are converted to prostacyclin in arterial endothelium, acting as a vasodilator and potent inhibitor of platelet aggregation.

Moreover, platelets contribute significantly to the intrinsic clotting pathway by releasing platelet factor 3 (PF 3), which facilitates the conversion of prothrombin to thrombin by factors X and V.



PHAGOCYTOSIS

Carbon particles, viruses and immune complexes are phagocytosed by platelet.

STORAGE & TRANSPORT

Store 5-HT, histamine, epinephrine & potassium. They can also take up 5-HT

by active transport.

NON HEMATOLOGICAL FUNCTIONS OF PLATELETS

INFLAMMATION:

Platelets share four characteristics common to all inflammatory cells:

1. They contain a diverse array of inflammatory mediators.

2. Platelets possess receptors for interaction with other inflammatory cells.

3. They have the capability to respond to harmful stimuli.

4. Platelets exhibit cooperation with other inflammatory cells.

Platelets play significant roles in various physiological processes:

Platelet-Derived Growth Factors:

Platelets release several growth factors, including Platelet-Derived Growth Factor (PDGF), Epidermal Growth Factor (EGF), and Fibroblast Growth Factor (FGF) from their alpha granules.

Platelets as Neurotransmitter Reservoirs:

Studies have demonstrated that platelets exhibit similar functionality to serotonergic neurons within the Central Nervous System (CNS), despite originating from different embryological pathways. This resemblance provides a valuable model for studying neuronal behavior.

Platelets and Metastasis:

Platelets aid in the survival of tumor cells within the bloodstream by shielding them from Natural Killer (NK) cell attacks, thereby promoting metastasis.

Platelets in Asthma:

The release of Platelet-Activating Factor (PAF) and Platelet Factor 4 (PF4) from platelets contributes to bronchial hyperreactivity observed in asthma.

STRUCTURAL, FUNCTIONAL AND METABOLIC

ALTERATIONS OF PLATELETS IN DIABETES MELLITUS

Numerous structural, functional, and metabolic alterations occur in the platelets of diabetic patients, leading to a prothrombotic state characterized by increased activation of coagulation proteins and platelets, coupled with decreased fibrinolytic activity.

Enhanced Platelet Activation:

In diabetic patients, circulating platelets exhibit signs of in vivo activation, including frequent granule release, which accelerates their sequestration in the circulation. This increased turnover rate reflects heightened thrombopoiesis. Platelet activation is further facilitated by altered response to agonists, increased adhesive proteins, enhanced glycoprotein receptor expression, reduced membrane fluidity, and elevated fibrinogen binding.

Platelet Hyperaggregability:

Diabetic patients demonstrate heightened platelet aggregation in response to various stimuli like ADP, collagen, thrombin, epinephrine, and arachidonic acid. These platelets exhibit a reduced threshold for aggregation, particularly evident in those with macrovascular disease. Adhesiveness, spontaneous aggregation, and aggregation on extracellular matrix are also elevated in diabetic platelets.

Increased Arachidonic Acid Metabolism:

The activation of the arachidonic acid pathway leads to increased TXA2 formation, phosphoinositide turnover, enhanced protein phosphorylation, and elevated inositol trisphosphate production, culminating in accelerated calcium mobilization. TXA2, a

potent platelet activator, is increased both in vitro and in vivo in diabetic patients, with HbA1c levels directly influencing thromboxane metabolism.

Increased Calcium Flux:

Diabetic patients exhibit heightened calcium mobilization from intra-platelet storage pools, leading to elevated intracellular free calcium levels. This increase correlates with decreased membrane fluidity and platelet hyperfunction. Additionally, reduced intracellular magnesium concentrations contribute to enhanced platelet adhesiveness and hyperaggregability.

Platelet Nitric Oxide Synthesis:

Diabetic platelets produce less prostacyclin and nitric oxide (NO), which typically inhibit platelet-endothelium interaction and induce endothelium-mediated vasodilation. Insulin stimulates NO synthesis in platelets.

Platelet Secretory Products:

Activated platelets release mitogenic and chemotactic factors. In diabetic patients, elevated levels of thromboglobulin and PF-4 in plasma are observed.

Platelet Membrane Glycation:

Hyperglycemia induces non-enzymatic glycation of platelet membrane proteins, altering their structure and conformation, as well as lipid membrane dynamics. This results in reduced membrane fluidity and increased expression of receptors vital for platelet functions, such as αIIbβ3.

Membrane Glycation of Low-Density Lipoproteins:

Glycation of low-density lipoproteins (LDL) contributes to increased platelet sensitivity to aggregating agents. Hyperglycemia leads to elevated levels of non-enzymatically glycated LDL (glycLDL), promoting oxidative stress and inhibiting Ca2+-ATPase and Na+/K+-ATPase activity in platelet membranes, further impairing platelet function and increasing thromboxane generation during activation.

EXPRESSION OF INCREASED SURFACE MARKERS ON PLATELET MEMBRANE

Increased expression and activity of several platelet-specific glycoprotein receptors (GP) have been observed in platelets from diabetic patients, including an increase in platelet αIIbβ3 receptor expression, which is associated with enhanced aggregability and fibrinogen binding. The up-regulation of the CD40-CD40 ligand system has also been noted in diabetic patients, leading to the shedding of CD40L and P-selectin from the platelet surface into plasma in a soluble, biologically active form. Elevated levels of these compounds may indicate a prothrombotic state and contribute to accelerated atherosclerosis. Additionally, diabetic patients exhibit increased collagen-induced aggregation.

Hyperglycemia is a well-established causal factor for platelet hyperactivity and in vivo platelet activation in diabetes mellitus patients. Glucose concentration inside platelets mirrors extracellular levels due to insulin-independent glucose entry. Metabolic alterations in platelets, including impaired calcium homeostasis, reduced platelet-derived nitric oxide production, activation of PKC, and increased superoxide anion formation, contribute to increased sensitivity to agonists. Furthermore, diabetic patients show reduced levels of glutathione and nitric oxide synthase activity in platelets.

Diabetic patients often have larger platelets circulating, attributed to increased megakaryocyte activation and ploidy. Larger platelets are believed to be more aggregable and reactive, with denser granules and higher secretion of beta thromboglobulin, serotonin, and TX A2 compared to smaller platelets. Platelet size correlates with thromboxane synthesizing capacity, GP molecule number on platelet membrane, and platelet granule concentration. Increased mean platelet volume (MPV) is associated with proliferative diabetic retinopathy.

Some studies suggest decreased platelet survival in diabetics with overt vascular complications. Platelets also influence leukocyte activation, chemotaxis, and phagocytosis through PDGF release, which enhances phagocytosis by monocytes and neutrophils, and through the release of P-selectin and nitric oxide, inhibiting leukocyte chemotaxis, adhesion, and superoxide generation.

Insulin resistance and metabolic syndrome in diabetes correlate with a prothrombotic state, exacerbating vascular complications. Insulin exhibits antiplatelet effects, including attenuation of thrombin-induced Ca2+ response and altered Ca2+ homeostasis in platelets. Reports suggest decreased binding of PGI2 with insulin in non-diabetic patients with acute ischemic heart disease, but insulin administration in coronary heart disease normalizes platelet activity to PGI2 levels. Vitamin E deficiency contributes to platelet aggregation, which can be mitigated by α-tocopherol supplementation. Insulin therapy may improve platelet sensitivity to nitric oxide, offering a potential strategy for treating cardiovascular diseases in diabetic patients.

Bhattacharjee et al.[19] conducted a study in 2016 titled “Platelet indices in diabetics and influence of glycemic control – a hospital-based study in North-East India.” Their research involved individuals aged over 12 years. The mean platelet volume (MPV)

among diabetics was 12.65 ± 1.89 fL, whereas non-diabetics exhibited an MPV of 11.16 ± 1.18 fL. Additionally, the platelet distribution width (PDW) in diabetics was recorded as 17.98 ± 3.43%, whereas non-diabetics displayed a PDW of 14.55 ± 2.29%. Furthermore, the platelet-large cell ratio (P-LCR) was 41.73 ± 11.9% in diabetics and 36.99 ± 8.56% in non-diabetics. Their analysis revealed that platelet indices were significantly elevated in diabetics compared to non-diabetics. Moreover, among diabetics, those with poor glycemic control (HbA1C > 7%) exhibited higher platelet indices compared to those with good glycemic control (HbA1C < 7%) (p-value < 0.05).

Umarani et al.,[20] concluded that the involved 100 participants. Among individuals with diabetes, the mean value of mean platelet volume (MPV) was 9.64 ± 0.81, whereas in those without diabetes, it was 8.66 ± 0.58. Regarding platelet count (PC), diabetics exhibited a mean value of 284.21 ± 79.41, whereas non-diabetics had a mean value of 298.18 ± 78.11. The study revealed a statistically significant variance in mean platelet volume between the diabetic and non-diabetic groups ($p < 0.001$). However, there was no statistically significant difference in platelet count between the two groups ($p = 0.309$).

Tanima Dwivedi et al.[21] (2018) concluded that out of 210 patients, 146 (69.2%) were males and 64 (30.8%) were females. The majority of patients were in age group of 40-59 years (mean age of the study group was 57.7±10.95 years and ranged between 29-82 years). Mean MPV of the study group was 8.6±1.24 fL, and range was 5.2-11.1 fL Mean PDW was 17.9±3.75 fL and range was 11.6-35.6 fL Mean PLCR was 35.5±7.88% and range were 12.9-49.4%. They concluded that on comparing various parameters between patients suffering from diabetes with good glycemic control and diabetic patients with bad glycemic control, it was observed that all the platelet indices

(MPV, PDW and PLCR) were higher in later patients and these differences were statistically significant.

Kumari Shilpi et al.[22] (2018) found that blood glucose parameters (HbA1c) exhibited statistically significant elevation in diabetics compared to non-diabetics (p value<0.001). Furthermore, the study evaluated MPV, PDW, and P-LCR in both diabetic and non-diabetic cohorts. The mean MPV among diabetic cases was 11.3 ± 1.0 fL, whereas in non-diabetics, it was 9 ± 0.6 fL, with a p value of 0.004. Similarly, mean PDW and P-LCR in diabetic patients were 14.2 ± 2.5 fL and 35.0 ± 8.1%, respectively, in contrast to non-diabetics where it measured 10.7 ± 0.7 fL and 23.0 ± 2.4%, respectively. The study noted a highly significant p value for MPV, PDW, and P-LCR in diabetic patients (p<0.05).

Karthikeyan T.M. et al.[23] (2021) research revealed that 76% of diabetic patients exhibited elevated median platelet volume, whereas 24% of diabetic patients showed median platelet volume within the normal range. Conversely, among the control population, 19% demonstrated increased mean platelet volume, while 81% had mean platelet volume within the normal range. Furthermore, the study noted that the median platelet distribution width (PDW) was notably higher in the diabetic population (21%) compared to the control group (11%). Both mean platelet volume and platelet distribution width were found to be higher in the diabetic population compared to the non-diabetic group, with a statistically significant difference between them (p < 0.001).

Materials & Methods

MATERIALS AND METHODS

- **Organization of study**- The proposed study entitled "EVALUATION OF PLATELET INDICES IN TYPE 2 DIABETES MELLITUS" was organized at Santosh Medical College and Hospital, Ghaziabad.

- **Study setting-** Central Clinical Laboratory, Pathology department, Santosh Medical College and Hospital, Ghaziabad, U.P

- **Study Design:** Hospital-based Case-Control Study.

- **Study Population**: -**Case:** This study included both men and women aged 35 to 60 years who attended the Medicine OPD. The **control group** consisted of healthy men and women aged 35 to 60 years.

- **Sample Size**: *n*=152 (76 cases & 76 Controls)

- **Sample Size Determination**:

$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2)\,(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2} = n_2$$

Where, n_1= sample size of group 1, i.e., 76

n_2= sample size of group 2, i.e., 76

σ_1= standard deviation of group 1, i.e., 41.73

σ_2= standard deviation of group 2, i.e., 36.99

$z_{1-\alpha/2}$= 1.96 for 95% confidence interval

$z_{1-\beta}$= 0.84 for 80% power

Δ= difference in group means, i.e., 41.73-36.99 = 4.74

(**Sample Size Formula** reference- Bernard Rosner. Fundamentals of Biostatics (5^{th} edition) (based on equation 8.27)

- **Inclusion criteria**
- **CASE GROUP-**

1- Diagnosed cases of Diabetes Mellitus. (According to WHO)

2- Age and Sex matched with healthy control.

3- Subjects who will give consent to be included in this study.

- **CONTROL GROUP-**

1- Healthy controls with normal blood glucose levels.

2- Age and Sex matched with case group.

3- Subjects who will give consent to be included in this study.

- **Exclusion criteria**

1. Male patients with haemoglobin <13gm/dL and female patients with haemoglobin <11gm/dL. (According to WHO)
2. Nondiabetic subjects with coronary artery disease.
3. Patients with any diagnosed acute febrile illness, malignancy, thrombocytopenia, or thrombotic disorders.

4. Patients on anti-platelet drugs such as aspirin, clopidogrel, etc.

5. Pregnant women.

Methodology

- The study was conducted on CBC and HbA1c in samples received from diabetic patients and healthy controls above 35 years.
- The sample size and sample frame consisted of 76 cases (diagnosed diabetic patients) and 76 controls (healthy and matched).
- Data on their clinical history, blood sugar levels, and complete blood counts were collected.
- In a cross-sectional design, the correlation between platelet parameters and HbA1c in patients above 20 years was described.
- SPSS Statistics version 29 trial was used for statistical analyses in this study.

Collection of data

- A total of 5ml of venous blood was collected, under aseptic conditions, in an EDTA vial.
- The EDTA samples were used for the estimation of CBC and HbA1c.
- All blood count studies were carried out with the Erba-360 Five Parts Auto Analyzer in the Department of Pathology.
- All glycosylated hemoglobin estimation was carried out on the COBAS-c 311 in the Department of Biochemistry.
- The findings were entered into a master chart and correlated with clinical and other relevant information available and then statistically analyzed.

Data Analysis

- The data was collected and entered in MS Excel 2016. Different statistical analyses were performed using software version SPSS Statistics 29 trial.
- Graphical representations of the variables were shown to understand the results clearly, and the association for categorical datasets was analyzed using the Independent Sample t-test.
- Correlation was estimated to measure the strength of the relationship between two or more quantitative variables.
- A p-value < 0.05 was considered statistically significant, and a p-value > 0.05 was considered statistically insignificant.

Results

RESULTS

Table 1: Distribution of age

	Cases vs. controls		
Age Range	**Cases**	**Controls**	**Total**
31-35	2	4	6
36-40	14	17	31
41-45	10	17	27
46-50	19	13	32
51-55	13	11	24
56-60	18	14	32
Total	76	76	152

χ^2=4.56, p=0.471

Table 1 shows the age distribution between the case group (patients with Type 2 Diabetes Mellitus) and the control group (healthy individuals). The age range of participants spans from 31 to 60 years. The largest groups fall within the 46-50 and 56-60 age ranges, with 32 participants each, followed by 36-40 years (31 participants). The smallest group is the 31-35 age range, with 6 participants. Statistical analysis using the chi-square test yielded a value of 4.56 with a p-value of 0.471, indicating no significant difference in the age distribution between cases and controls. Therefore, the groups are well-matched in terms of age.

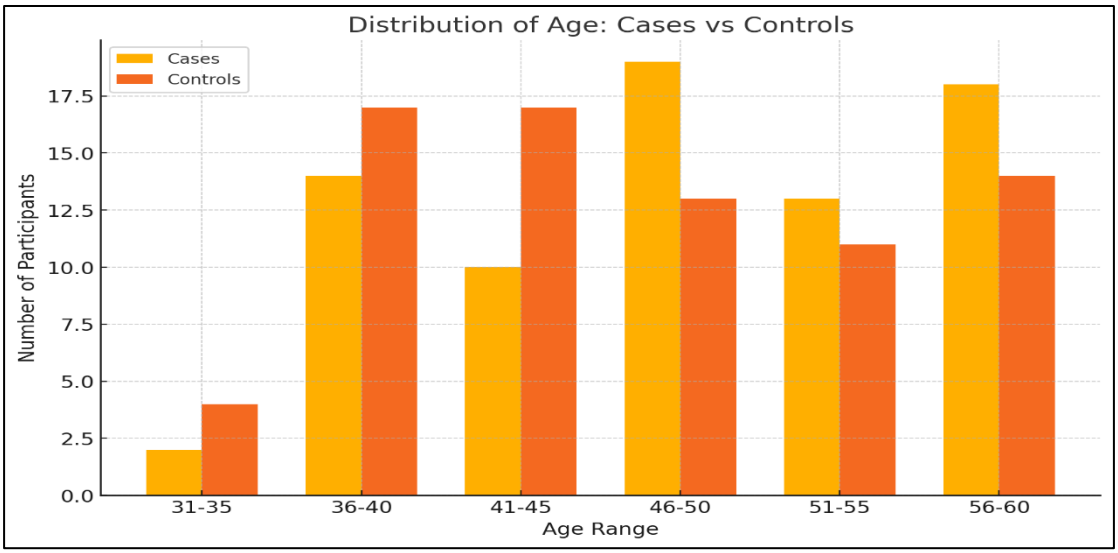


Figure 1: "Distribution of age"

Table 2: Distribution of gender

	Cases vs. controls		
Gender	**Cases**	**Controls**	**Total**
Male	46	43	89
Female	30	33	63
Total	76	76	152

χ^2=0.244, p=0.621

Table 2 presents the gender distribution among the cases (patients with Type 2 Diabetes Mellitus) and controls (healthy individuals). Of the total 152 participants, 89 are male, with 46 in the case group and 43 in the control group. There are 63 females, 30 among the cases and 33 among the controls. The chi-square test result is 0.244, with a p-value of 0.621, indicating no statistically significant difference in gender distribution between the two groups. This suggests that both groups are well-matched for gender, reducing the likelihood of gender-related bias in the analysis.

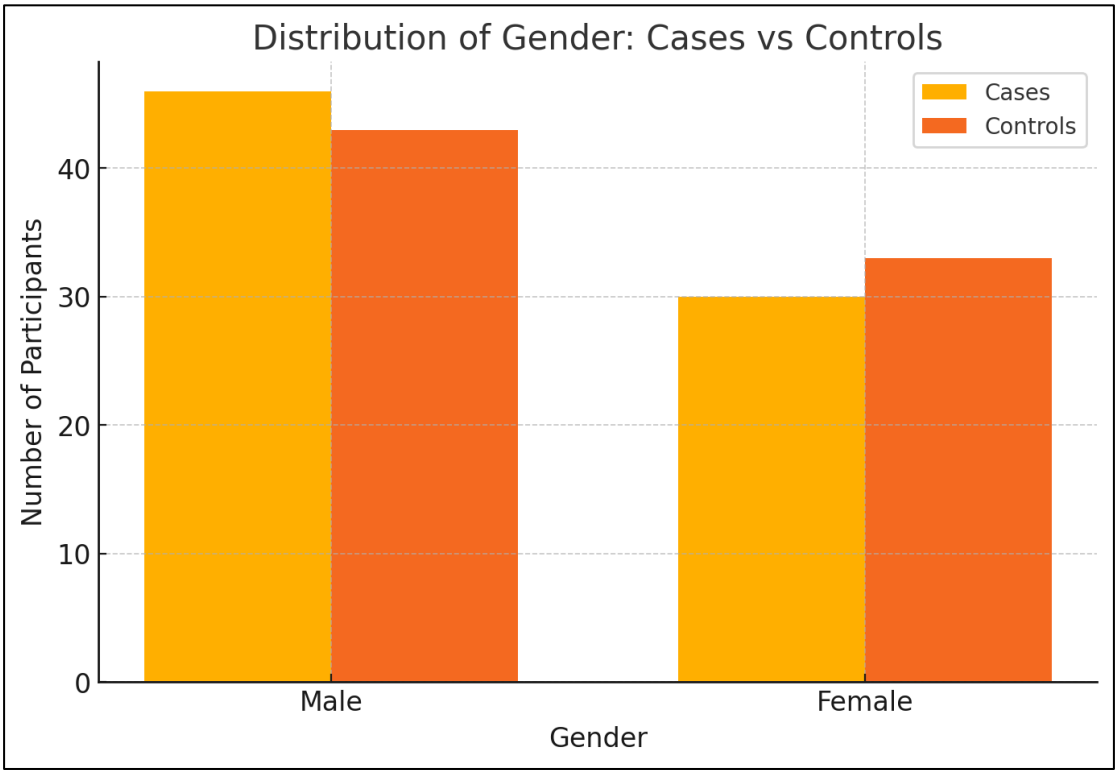


Figure 2: "Distribution of gender"

Table 3: Distribution of common symptoms

	Cases vs. controls		
Common Symptoms	**Cases**	**Controls**	**Total**
No	8	76	84
Malaise, Polyuria	11	0	11
Polyuria, Blurry vision	13	0	13
Weight loss, Weakness	12	0	12
Polyphagia, Polydipsia	17	0	17
Difficulty in breathing, Polyphagia	15	0	15
Total	76	76	152

χ^2=123,p= <0.001

Table 3 presents the distribution of common symptoms among the case group (Type 2 Diabetes Mellitus patients) and the control group (healthy individuals). While 84 participants (8 cases and 76 controls) reported no symptoms, various symptom combinations were exclusively present in the case group. These included malaise and polyuria (11 cases), polyuria with blurry vision (13 cases), weight loss with weakness (12 cases), polyphagia with polydipsia (17 cases), and difficulty breathing with polyphagia (15 cases). The chi-square test result is 123, with a p-value of <0.001, indicating a statistically significant difference in symptom distribution between the groups. This highlights the symptomatic burden experienced by diabetic patients compared to healthy controls.

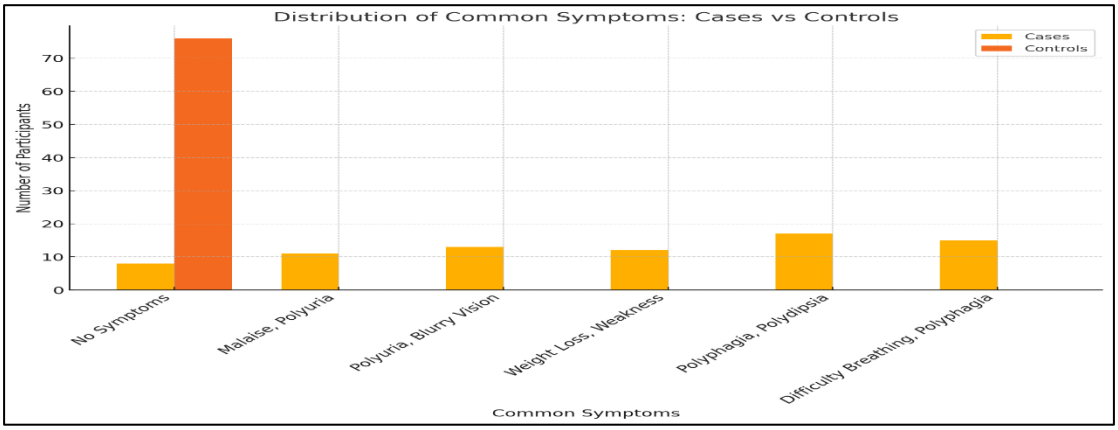


Figure 3: "Distribution of common symptoms"

Table 4: Distribution of Diabetes Complications among Cases and Controls

	Diabetic or Non-Diabetic		
Diabetes Complications	**Diabetic**	**Non-Diabetic**	**Total**
Absent	12	76	88
Diabetic foot	16	0	16
Retinopathy	11	0	11
Nephropathy	8	0	8
Cardiovascular	6	0	6
Cerebrovascular	13	0	13
Multiple complications	10	0	10
Total	76	76	152

χ^2=111, p=<0.001

Table 4 presents the distribution of diabetes-related complications between diabetic and non-diabetic participants. Out of the 76 diabetic individuals, 64 (84.2%) reported one or more complications, while 12 (15.8%) did not experience any. The complications observed among diabetic patients include diabetic foot (16 cases), retinopathy (11 cases), nephropathy (8 cases), cardiovascular complications (6 cases), cerebrovascular conditions (13 cases), and multiple complications (10 cases). On the other hand, all 76 non-diabetic participants were free from diabetes-related complications, falling exclusively under the "Absent" category. The chi-square test resulted in a χ^2 value of 111 with a p-value of <0.001, indicating a statistically significant difference in the occurrence of complications between the two groups. These findings highlight the substantial burden of complications associated with diabetes and emphasize the need for effective clinical management strategies to mitigate these risks among diabetic patients.

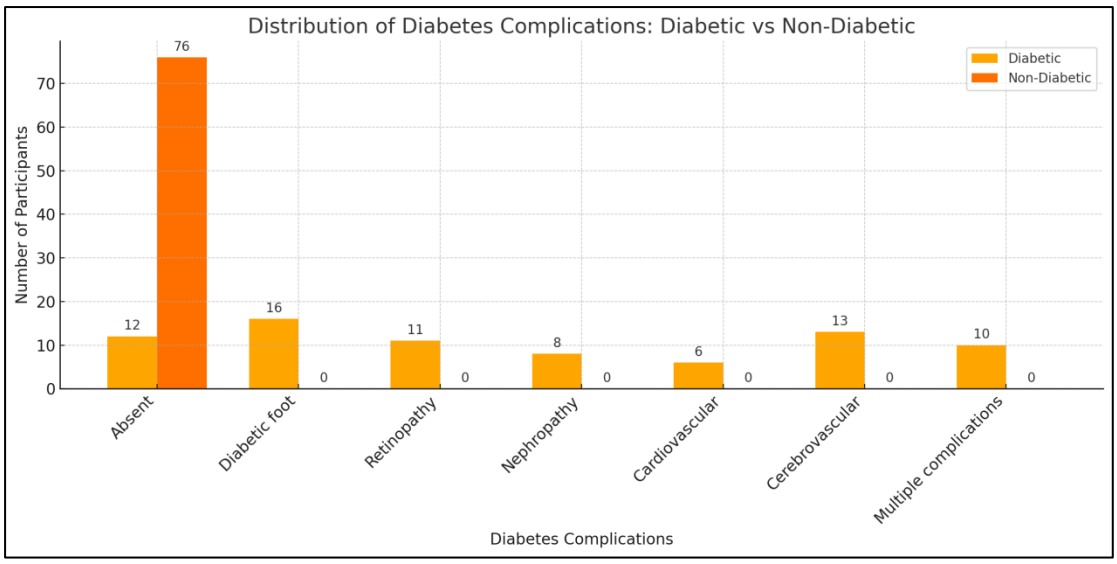


Figure 4: "Distribution of Diabetes Complications among Cases and Controls"

Table 5: Comparison of platelet indices between Cases and controls

	Cases vs. controls		
Platelet indices	**Cases**	**Controls**	**P value**
MPV (fL)	6.73 ± 1.45	3.42 ± 0.45	<0.001
PDW (fL)	10.4 ± 2.05	5.21 ± 0.57	<0.001
P-LCR (%)	21.7 ± 4.43	10.8 ± 1.35	<0.001
Platelet Count (10^9/L)	257 ± 73.7	232 ± 45.1	0.015

Table 5 presents the comparison of platelet indices between Type 2 Diabetes Mellitus (cases) and healthy controls. The mean platelet volume (MPV) is significantly higher in cases (6.73 ± 1.45 fL) compared to controls (3.42 ± 0.45 fL), with a p-value of <0.001. Platelet distribution width (PDW) is also elevated in cases (10.4 ± 2.05 fL) versus controls (5.21 ± 0.57 fL), with a p-value of <0.001. Similarly, the platelet-large cell ratio (P-LCR) is higher in cases (21.7 ± 4.43%) than in controls (10.8 ± 1.35%), with a p-value of <0.001. The platelet count is slightly elevated in cases (257 ± 73.7) compared to controls (232 ± 45.1), with a statistically significant p-value of 0.015. These findings suggest altered platelet indices in diabetic patients, indicating potential vascular risks.

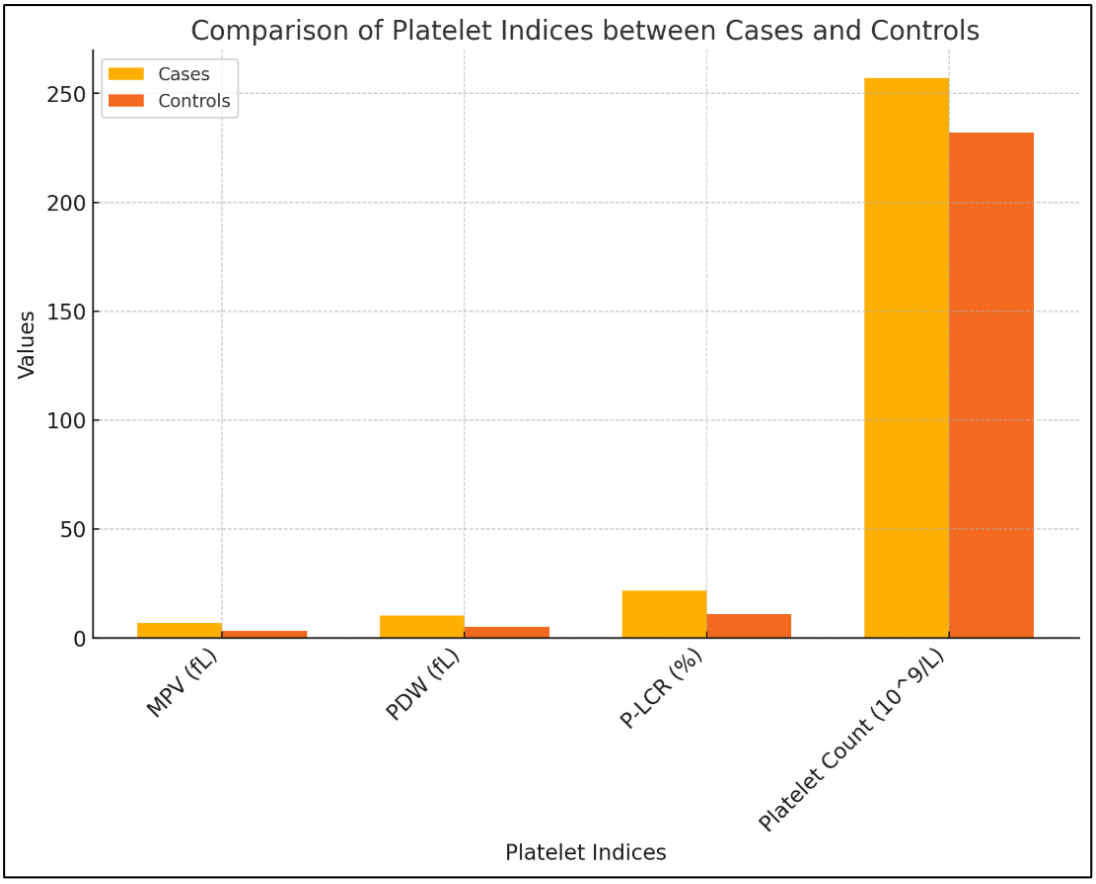


Figure 5: "Comparison of platelet indices between Cases and controls"

Table 6: Comparison of platelet indices between diabetics with good control to diabetics with poor control

	Glycemic control status		
Platelet indices	**Poor Control**	**Good Control**	**P value**
MPV (fL)	6.97 ± 1.35	3.55 ± 0.59	<0.001
PDW (fL)	10.8 ± 1.81	5.4 ± 0.81	<0.001
P-LCR (%)	22.4 ± 4.06	11.3 ± 1.85	<0.001
Platelet Count (10^9/L)	256 ± 74.7	236 ± 48.3	0.048

Table 6 compares platelet indices between diabetic patients with poor glycemic control and those with good control. The mean platelet volume (MPV) is significantly higher in poorly controlled diabetics (6.97 ± 1.35 fL) compared to those with good control (3.55 ± 0.59 fL), with a p-value of <0.001. Platelet distribution width (PDW) also shows a significant increase in the poor control group (10.8 ± 1.81 fL) compared to the good

control group (5.4 ± 0.81 fL), with a p-value of <0.001. Similarly, the platelet-large cell ratio (P-LCR) is elevated in the poor control group (22.4 ± 4.06%) compared to the good control group (11.3 ± 1.85%), with a p-value of <0.001. The platelet count is also slightly higher in the poor control group (256 ± 74.7) compared to the good control group (236 ± 48.3), with a p-value of 0.048. These findings suggest that poor glycemic control is associated with altered platelet indices, potentially increasing the risk of vascular complications.

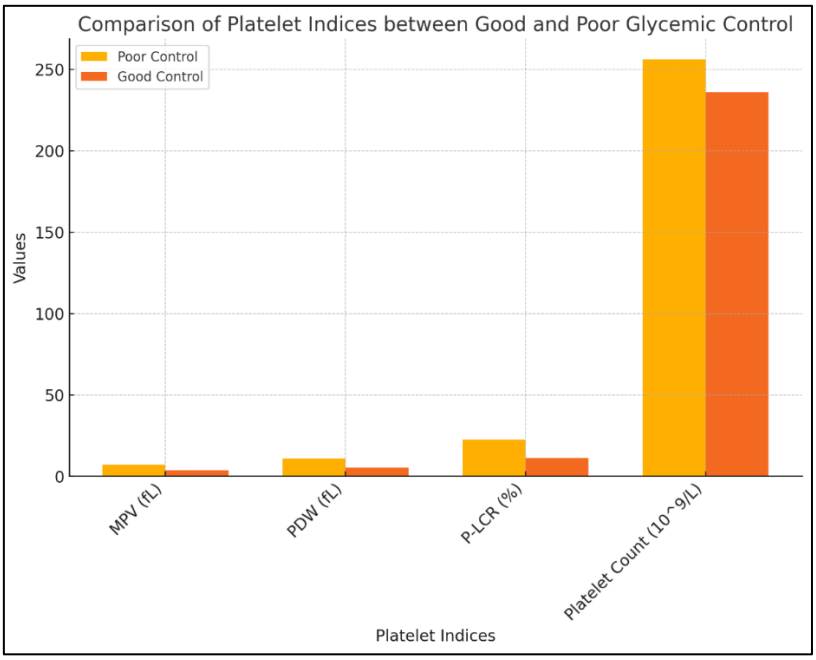


Figure 6: "Comparison of platelet indices between diabetics with good control to diabetics with poor control"

Table 7: Comparison of mean MPV between Age groups.

Age Range	**MPV (fL) (Mean ± SD)**
31–35	4.95 ± 1.78
36–40	4.64 ± 1.67
41–45	4.51 ± 1.90
46–50	5.68 ± 2.14
51–55	5.40 ± 2.20
56–60	5.16 ± 1.93

Table 7 presents the comparison of mean MPV (Mean Platelet Volume) across different age groups. The mean MPV varies slightly across the age ranges, with the lowest value observed in the 41–45 age group (4.51 ± 1.90 fL) and the highest in the 46–50 age group (5.68 ± 2.14 fL). Participants in the 31–35, 36–40, 51–55, and 56–60 age groups show mean MPV values of 4.95 ± 1.78 fL, 4.64 ± 1.67 fL, 5.40 ± 2.20 fL, and 5.16 ± 1.93 fL, respectively. The data indicate a modest variation in MPV across age groups, suggesting age-related changes in platelet size. However, further statistical analysis is required to determine if these differences are significant.

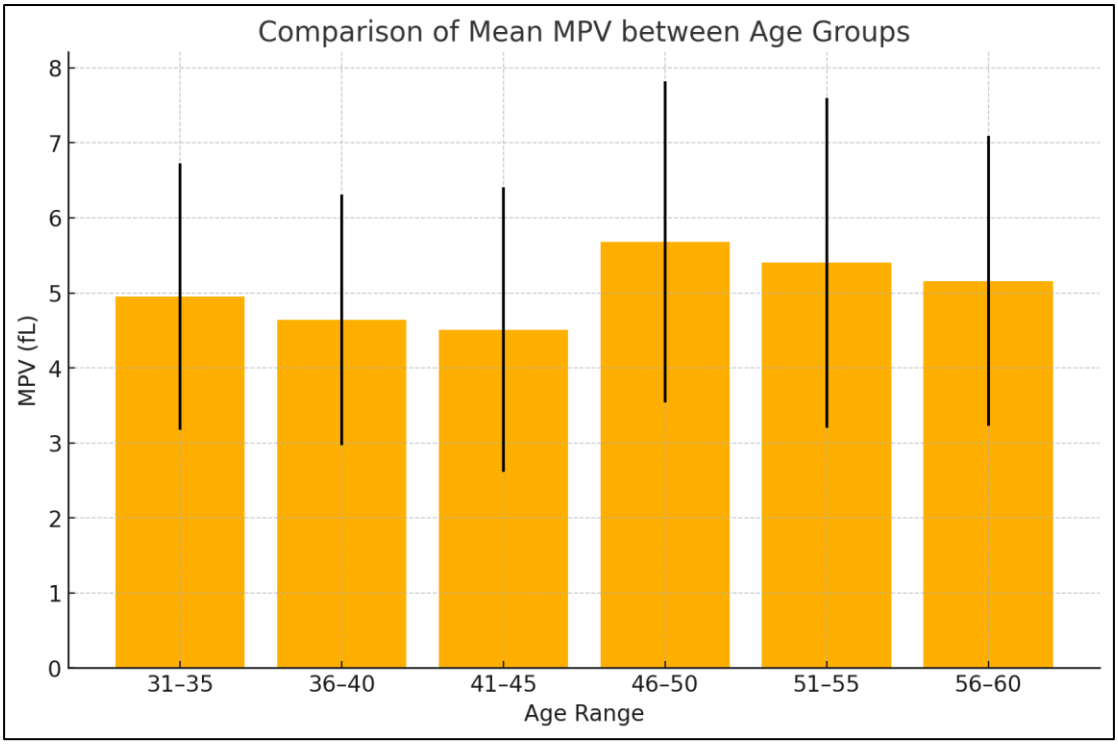


Figure 7: "Comparison of mean MPV between Age groups"

Table 8: Comparison of mean MPV among gender

Gender	**Male**	**Female**	**P value**
MPV (fL)	5.16 ± 2.07	4.95 ± 1.85	0.520

Table 8 presents the comparison of mean MPV (Mean Platelet Volume) between male and female participants. The mean MPV for males is 5.16 ± 2.07 fL, while for females, it is 4.95 ± 1.85 fL. The p-value for the comparison is 0.520, indicating no statistically significant difference in MPV between genders. This suggests that platelet size, as

measured by MPV, is comparable between male and female participants, and gender does not appear to influence MPV significantly in this study population.

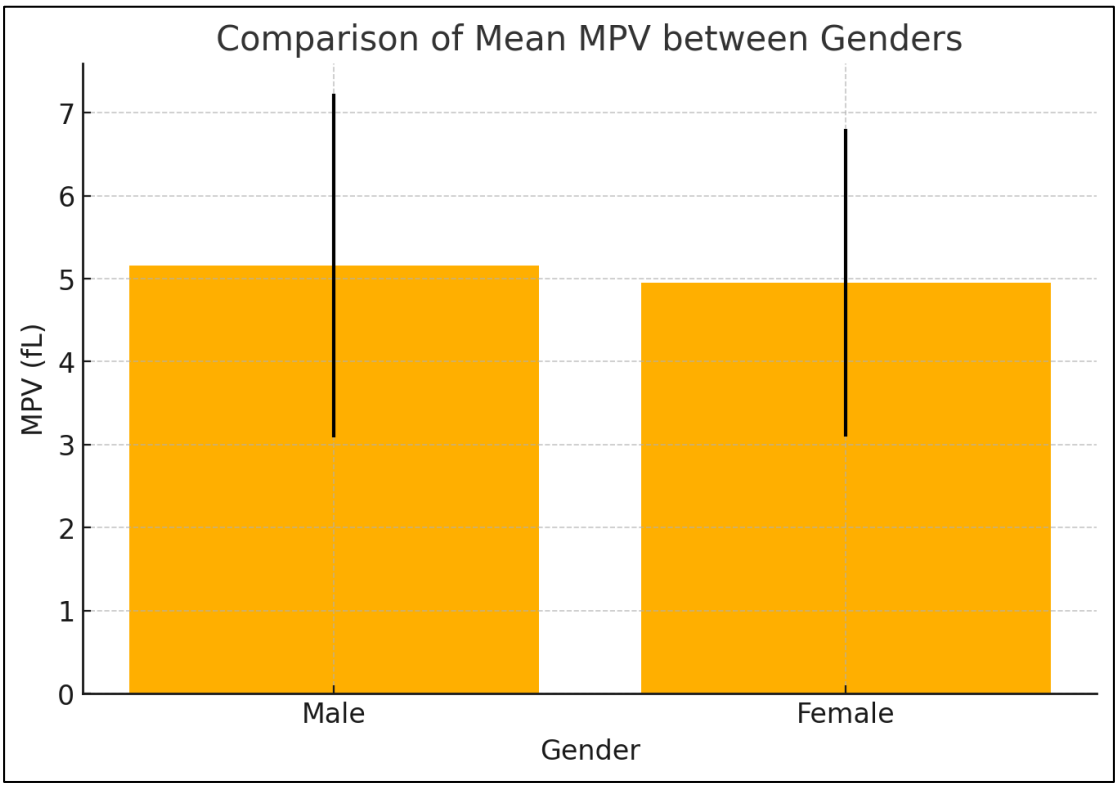


Figure 8: "Comparison of mean MPV among gender"

Table 9: Comparison of Platelet indices with duration of DM

	Platelet indices (Mean ± SD)			
Duration of Diabetes (Years)	**MPV (fL)**	**PDW (fL)**	**P-LCR (%)**	**Platelet Count (10^9/L)**
1–5	7.13 ± 1.84	11.0 ± 2.5	22.1 ± 4.19	292 ± 74.2
5–10	6.68 ± 1.41	10.3 ± 2.0	21.4 ± 4.3	253 ± 69.4
>10	6.67 ± 1.35	10.5 ± 2.03	22.7 ± 5.73	243 ± 95.7
P value (Anova test)	0.657	0.699	0.695	0.259

Table 9 compares platelet indices with the duration of diabetes mellitus (DM) across three groups: 1–5 years, 5–10 years, and >10 years. The mean MPV is highest in the 1–5 years group (7.13 ± 1.84 fL) and slightly lower in the 5–10 years (6.68 ± 1.41 fL)

and >10 years (6.67 ± 1.35 fL) groups, with a non-significant p-value of 0.657. PDW and P-LCR values show similar patterns without significant differences (p = 0.699 and 0.695, respectively). The platelet count decreases with the duration of diabetes but remains statistically non-significant (p = 0.259). These findings suggest no significant correlation between platelet indices and the duration of DM in this study population.

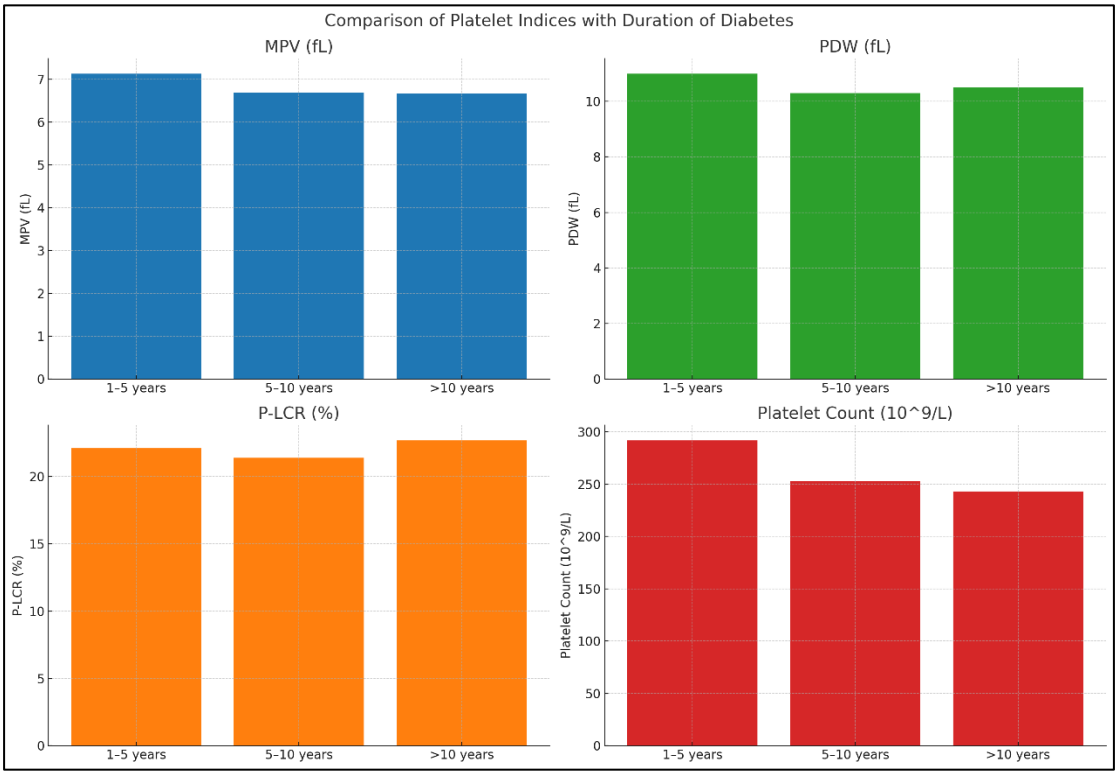


Figure 9: "Comparison of Platelet indices with duration of DM"

Table 10: Comparison of platelet indices with BMI

	Platelet indices (Mean ± SD)			
BMI Category	**MPV (fL)**	**PDW (fL)**	**P-LCR (%)**	**Platelet Count (10^9/L)**
Normal	4.92 ± 1.92	7.6 ± 3.05	15.7 ± 6.07	243 ± 62.7
Obese	7.31 ± 1.46	11.3 ± 1.19	24.6 ± 2.81	250 ± 61.6
Overweight	4.99 ± 1.96	7.67 ± 2.9	16 ± 6.34	246 ± 62.3
P value (Anova test)	0.004	0.003	<0.001	0.922

Table 10 compares platelet indices across different BMI categories: Normal, Overweight, and Obese. The mean MPV is significantly higher in obese individuals (7.31 ± 1.46 fL) compared to normal (4.92 ± 1.92 fL) and overweight (4.99 ± 1.96 fL) groups, with a p-value of 0.004. PDW also shows a significant increase in obese participants (11.3 ± 1.19 fL) compared to other groups, with a p-value of 0.003. P-LCR is notably higher in obese individuals (24.6 ± 2.81%) with a p-value of <0.001. However, the platelet count shows no significant difference across BMI categories (p = 0.922). These findings suggest that higher BMI, particularly obesity, is associated with altered platelet indices, potentially increasing the risk of vascular complications.

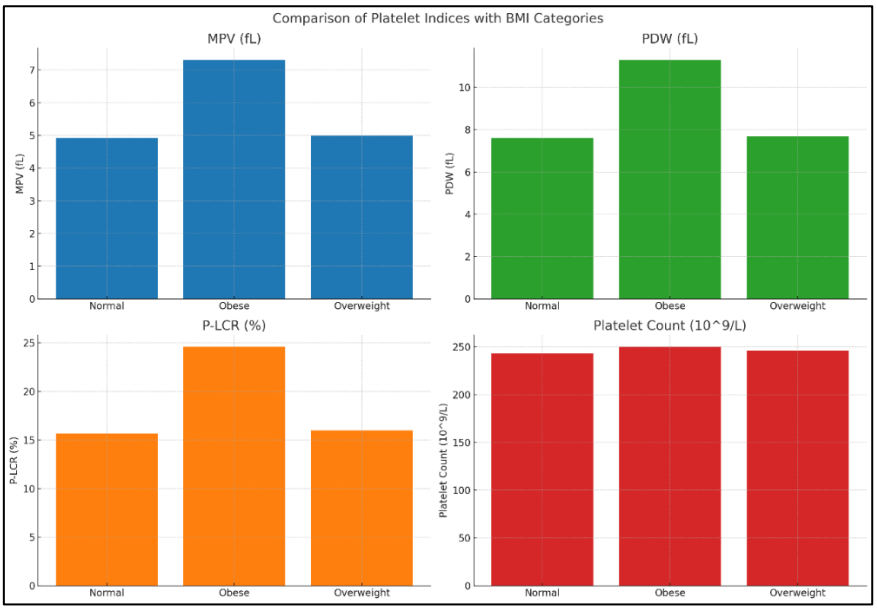


Figure 10: "Comparison of platelet indices with BMI"

Table 11: Distribution of subject according to HbA1c

	Platelet indices (Mean ± SD)			
HbA1c	**MPV (fL)**	**PDW (fL)**	**P-LCR (%)**	**Platelet Count (10^9/L)**
< 5.6	4.16 ± 1.62	6.35 ± 2.41	13.3 ± 5.19	239 ± 54.6
5.6–6.4	6.88 ± 1.61	10.5 ± 2.59	21.4 ± 5.10	249 ± 70.7
> 6.4	6.52 ± 1.42	10.3 ± 1.95	21.4 ± 4.41	258 ± 74.4
P value (Anova test)	<0.001	<0.001	<0.001	0.250

Table 11 presents the distribution of platelet indices according to HbA1c levels, categorized as <5.6, 5.6–6.4, and >6.4. The mean MPV increases significantly with higher HbA1c levels, from 4.16 ± 1.62 fL in the <5.6 group to 6.88 ± 1.61 fL in the 5.6–6.4 group ($p < 0.001$). Similarly, PDW and P-LCR also show significant increases with rising HbA1c levels, with p-values < 0.001. However, the platelet count shows no statistically significant difference across the HbA1c categories ($p = 0.250$). These findings indicate that higher HbA1c levels, reflective of poor glycemic control, are associated with elevated platelet indices, suggesting increased platelet activation and a higher risk of vascular complications in diabetic individuals.

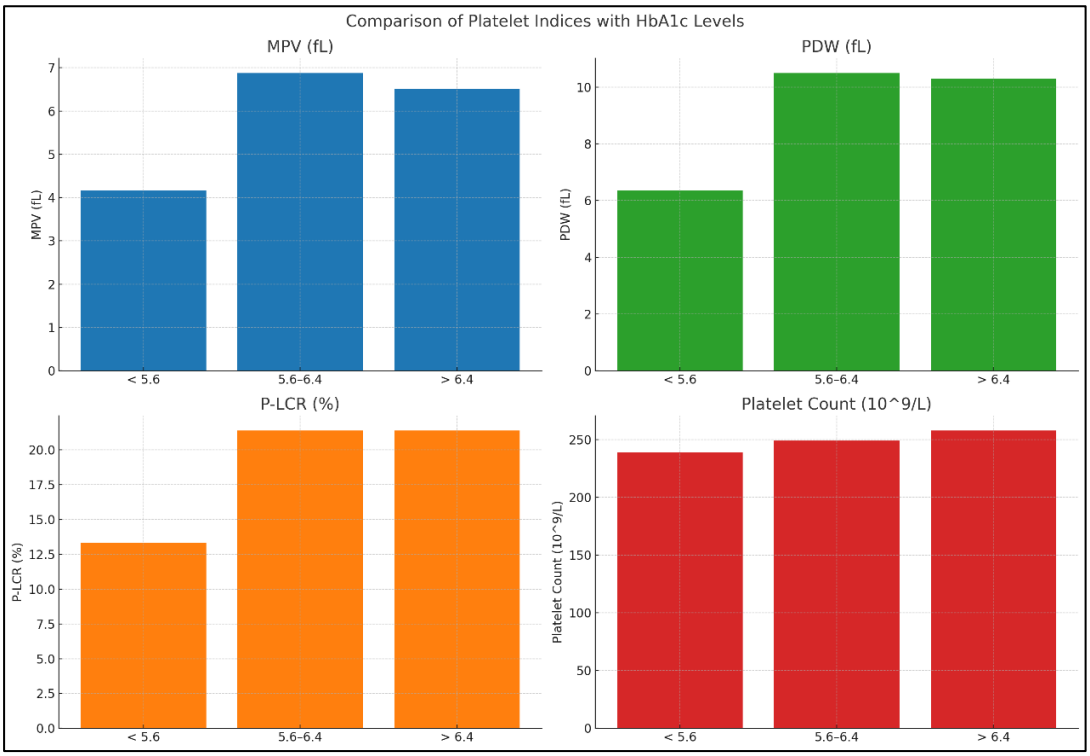


Figure 11: "Distribution of subject according to HbA1c"

Table 12: Comparison of BMI, BP and HbA1c

	Cases vs. controls		
Parameter	**Cases**	**Controls**	**P value**
BMI	25.3 ± 4.41	24.08 ± 3.27	0.054
Systolic BP (mmHg)	145.79 ± 8.60	119.61 ± 5.53	<0.001
Diastolic BP (mmHg)	88.99 ± 5.89	76.79 ± 4.32	<0.001
HbA1c levels	9.63 ± 1.85	4.78 ± 0.43	<0.001

Table 12 compares BMI, blood pressure (BP), and HbA1c levels between cases (Type 2 Diabetes Mellitus patients) and controls (healthy individuals). The mean BMI is slightly higher in cases (25.3 ± 4.41) compared to controls (24.08 ± 3.27), with a p-value of 0.054, indicating no significant difference. However, both systolic and diastolic BP are significantly elevated in cases (145.79 ± 8.60 mmHg and 88.99 ± 5.89 mmHg) compared to controls (119.61 ± 5.53 mmHg and 76.79 ± 4.32 mmHg), with p-values <0.001. HbA1c levels are also markedly higher in cases (9.63 ± 1.85) than in controls (4.78 ± 0.43), with a p-value <0.001. These results suggest that diabetic patients have significantly higher blood pressure and poorer glycemic control than non-diabetic individuals.

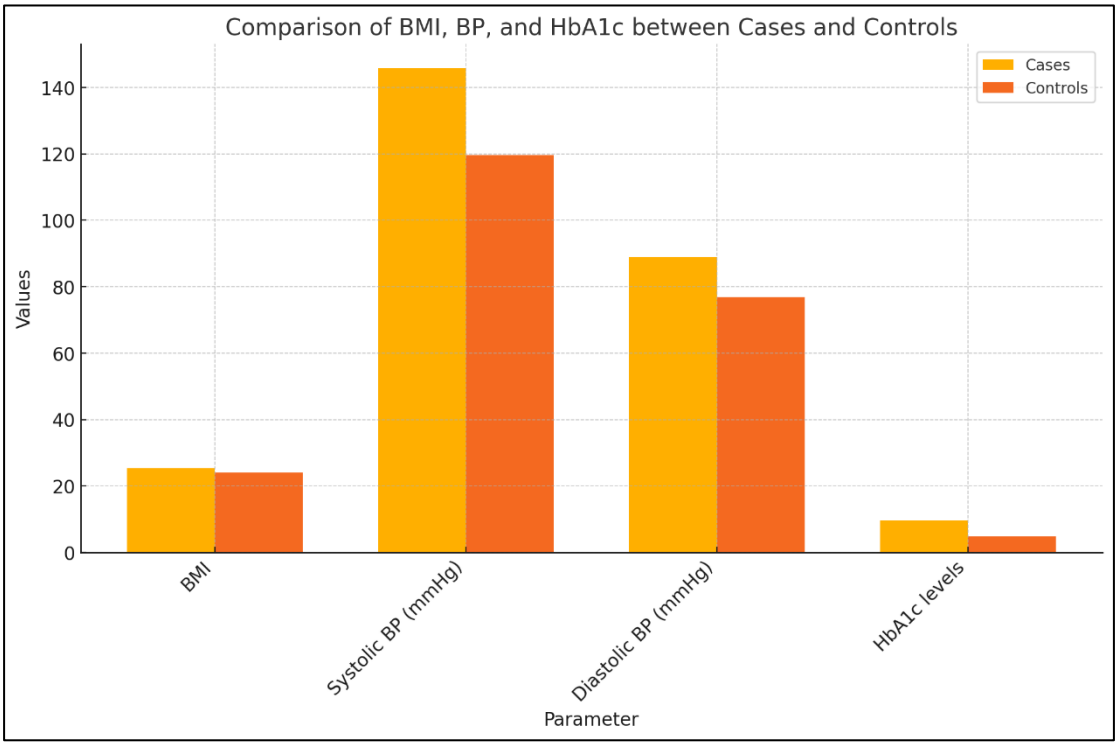


Figure 12: "Comparison of BMI, BP and HbA1c"

Table 13: Correlation matrix

		BMI	**HbA1c levels**	**MPV (fL)**	**PDW (fL)**	**P-LCR (%)**	**Platelet count (10^9/L)**
BMI	Pearson's r	—	0.14	0.111	0.117	0.146	0.104
	p-value	—	0.086	0.172	0.15	0.072	0.201
HbA1c levels	Pearson's r		—	0.967	0.982	0.978	0.234
	p-value		—	< .001	< .001	< .001	0.004
MPV (fL)	Pearson's r			—			0.229
	p-value			—			0.004
PDW (fL)	Pearson's r			0.954	—		0.217
	p-value			< .001	—		0.007
P-LCR (%)	Pearson's r			0.951	0.962	—	0.233
	p-value			< .001	< .001	—	0.004
Platelet count (10^9/L)	Pearson's r						—
	p-value						—

Table 13 presents the Pearson correlation analysis between BMI, HbA1c levels, platelet indices (MPV, PDW, P-LCR), and platelet count in Type 2 Diabetes Mellitus patients. A positive and highly significant correlation is observed between HbA1c levels and MPV ($r = 0.967$, $p < 0.001$), HbA1c and PDW ($r = 0.982$, $p < 0.001$), and HbA1c with P-LCR ($r = 0.978$, $p < 0.001$), suggesting that as glycemic levels increase, platelet activation parameters also increase. Similarly, MPV shows a significant association with PDW ($r = 0.954$, $p < 0.001$) and P-LCR ($r = 0.951$, $p < 0.001$), indicating a strong interrelationship among these platelet indices. Additionally, PDW is positively correlated with P-LCR ($r = 0.962$, $p < 0.001$). However, BMI shows weaker and statistically non-significant correlations with MPV ($r = 0.111$, $p = 0.172$), PDW (r =

0.117, p = 0.15), and P-LCR (r = 0.146, p = 0.072), implying that BMI may have a limited impact on platelet indices. Interestingly, a modest but significant correlation exists between HbA1c and platelet count (r = 0.234, p = 0.004), hinting at a possible association between glycemic control and platelet production. These findings underscore the potential of platelet indices as markers of glycemic status and platelet function in diabetic individuals, emphasizing their role in the early detection of complications in Type 2 Diabetes Mellitus.

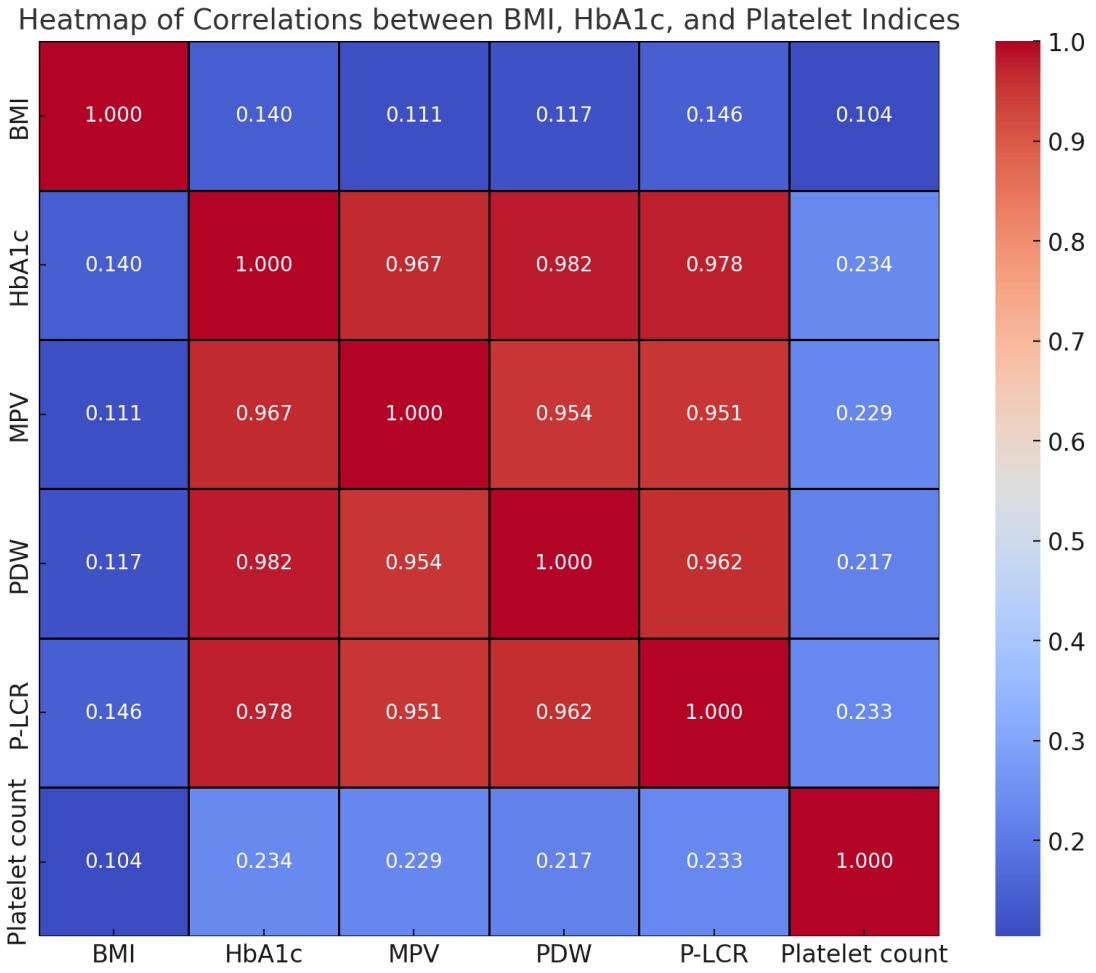


Figure 13: Heatmap of correlation matrix

Discussion

DISCUSSION

The present study found that the distribution of age among Type 2 Diabetes Mellitus (DM) patients (cases) and non-diabetic participants (controls) was comparable. A total of 152 participants were studied, divided equally into 76 cases and 76 controls. Among the diabetic cases, the largest age groups were 46–50 years (19 cases) and 56–60 years (18 cases). Similarly, in the control group, the majority were within the 36–40 years (17 controls) and 41–45 years (17 controls) age ranges. Statistical analysis using the χ^2 test showed no significant difference in the age distribution between the diabetic and non-diabetic groups ($\chi^2 = 4.56$, $p = 0.471$), indicating that both groups were age-matched, minimizing the impact of age as a confounding variable.The present study's findings align with those reported by **Shilpi and Potekar**,[24] who investigated platelet indices in 280 diabetic cases and 280 non-diabetic controls. In their study, participants ranged in age from 45 to 70 years, with the mean age of diabetic cases being 53 ± 5.7 years and the mean age of controls at 54.1 ± 5.2 years. This is consistent with the present study, where most diabetic patients were found in older age groups (46–60 years), emphasizing the higher prevalence of diabetes in middle-aged and elderly individuals. However, Shilpi et al. reported a slightly higher age range, possibly reflecting variations in study design or population demographics. Similarly, **Pujani et al.**[25] studied 30 diabetics with complications and 30 without, reporting a mean age of 50.87 ± 9.75 years for uncomplicated cases and 55.63 ± 7.49 years for those with complications. Their results indicated a significant difference in age between the two diabetic subgroups ($p = 0.038$), with older participants more likely to have complications. Although the present study did not focus on complications, it observed that the highest concentration of diabetic cases occurred between 46–60 years. This trend aligns with the findings

from Pujani et al., highlighting that older age groups are both more prone to diabetes and at higher risk for developing complications.

The present study found that the gender distribution between Type 2 DM patients (cases) and non-diabetic participants (controls) was comparable. Among the 152 participants, 46 males and 30 females were diabetic, while the non-diabetic controls included 43 males and 33 females. Statistical analysis using the χ^2 test indicated no significant difference in the gender distribution between cases and controls ($\chi^2 = 0.244$, $p = 0.621$). This suggests that both groups were well-matched in terms of gender, ensuring that gender did not act as a confounding factor in the study outcomes. The findings of the present study align with those reported by **Samaddar et al.**,[26] who studied platelet indices in 277 diabetic patients, including 193 (69.7%) in the controlled group and 84 (30.3%) in the uncontrolled group. In their study, the gender distribution within the controlled group was nearly balanced, with 98 males (50.78%) and 95 females (49.22%). Similarly, the uncontrolled group comprised 41 males (48.8%) and 43 females (51.19%). These results, much like the present study, demonstrated no significant gender predominance, suggesting that both male and female patients are equally likely to have diabetes, regardless of control status. In contrast, **Dwivedi and Davangeri**[27] reported a different gender distribution in their study, which included 210 diabetic patients attending a tertiary care hospital. They found that 146 (69.2%) of the participants were males and only 64 (30.8%) were females, indicating a male predominance in their cohort. This variation could be attributed to demographic differences or referral patterns to tertiary care centers. The present study's gender distribution aligns with findings from Samaddar et al. and Dwivedi and Davangeri, showing a slightly higher proportion of males among both diabetic (59%) and non-diabetic (56.6%) participants. While gender distribution varies across studies, there is

no consistent evidence of a strong gender bias in Type 2 DM prevalence, highlighting the importance of well-matched case-control studies to minimize gender-related confounding.

The present study found significant differences In symptom presentation between Type 2 DM patients (cases) and non-diabetic participants (controls). While all 76 non-diabetic controls reported no symptoms, the diabetic cases exhibited a variety of common symptoms. The most frequently reported symptoms among cases were polyphagia and polydipsia (17 cases), followed by difficulty in breathing with polyphagia (15 cases). Other reported symptoms included polyuria with blurry vision (13 cases), weight loss and weakness (12 cases), and malaise with polyuria (11 cases). The χ^2 test confirmed that the symptom distribution was highly significant ($\chi^2 = 123$, $p < 0.001$), indicating that these symptoms are strongly associated with Type 2 DM. The findings of the present study align with the results reported by **Taderegew et al.**,[28] who investigated the prevalence of microvascular complications among Type 2 DM patients. Their study found that 33.2% of participants experienced at least one microvascular complication, with 18.8% presenting with retinopathy, 11.1% with nephropathy, and 6.5% with neuropathy. This highlights the association between diabetes-related symptoms and progressive complications. While our study did not directly assess microvascular complications, the presence of symptoms like polyuria, blurry vision, and difficulty breathing in our diabetic cases may signal underlying complications or advanced disease stages, similar to the patterns observed by Taderegew et al. Additionally, **Dwivedi and Davangeri[27]** provided insights into the association of platelet indices with various diabetic complications. In their cohort of 210 patients, cardiovascular complications were most common (44.76%), followed by diabetic foot (22.38%) and retinopathy (2.38%). Though the present study focused on symptom

presentation rather than specific complications, symptoms such as weight loss, weakness, and polyuria observed in our diabetic cases may correlate with the early manifestation of complications like diabetic foot or nephropathy, as noted by Dwivedi and Davangeri[27] These comparisons further emphasize that symptomatology in diabetic patients is often linked with the development of significant complications, underscoring the need for early symptom recognition to prevent further deterioration.

The present study found significant differences In the prevalence of symptoms between Type 2 DM patients (cases) and non-diabetic participants (controls). Among the cases, common symptoms included polyphagia with polydipsia (17 cases), difficulty in breathing with polyphagia (15 cases), polyuria with blurry vision (13 cases), weight loss with weakness (12 cases), and malaise with polyuria (11 cases). In contrast, none of these symptoms were reported among the controls, with 76 controls having no symptoms at all. The χ^2 test showed a highly significant difference in symptom prevalence between cases and controls ($\chi^2 = 123$, $p < 0.001$), indicating that these symptoms are strongly associated with diabetes.The findings of the present study are consistent with those reported by **Drivsholm et al.**,[29] who analyzed symptoms in 1,137 newly diagnosed Type 2 DM patients. They found a high prevalence of abnormal thirst (63.7%), frequent urination (53.9%), unintended weight loss (34.8%), fatigue (61%), and visual disturbances (24.9%). Drivsholm et al. also observed that many symptoms persisted for extended periods before diagnosis, with thirst and frequent urination reported for more than six months by 29.8% and 29.7% of patients, respectively. The present study aligns with these findings, showing that polyphagia, polydipsia, weight loss, and polyuria are commonly reported by diabetic patients.

The present study found that 64 out of 76 diabetic patients (84.2%) experienced complications, while all non-diabetic participants had no complications. Among the diabetic patients, the most frequent complications were diabetic foot (16 cases), cerebrovascular complications (13 cases), retinopathy (11 cases), and multiple complications (10 cases). Nephropathy was present in 8 cases, and cardiovascular complications were observed in 6 cases. The χ^2 test demonstrated a highly significant difference in the prevalence of complications between diabetic and non-diabetic participants ($\chi^2 = 111$, $p < 0.001$), indicating that complications are a critical concern among diabetics. The findings of the present study align with those of **Dwivedi and Davangeri**,[27] who reported complications in 210 diabetic patients. In their study, 47 (22.38%) had diabetic foot, 94 (44.76%) experienced cardiovascular complications, 5 (2.38%) had retinopathy, and 5 (2.38%) developed nephropathy. The incidence of cerebrovascular events was lower, affecting only 2 (0.95%) patients. Multiple complications were reported in 4 (1.91%) cases. In comparison, the present study observed a higher prevalence of diabetic foot (21%) and cerebrovascular complications (17.1%), possibly due to differences in patient profiles or health care access. **Buch et al.**[30] also explored diabetic complications and their relationship with fasting blood sugar (FBS) and HbA1c. They found a significant association between coronary artery disease (55 cases) and higher FBS (188.87 ± 63.4 mg/dL, $p = 0.013$) as well as elevated HbA1c (9.16 ± 1.75%, $p = 0.048$). In the present study, cardiovascular complications were observed in 7.9% of diabetic patients. However, complications like diabetic foot and cerebrovascular events were more prevalent, suggesting variability in complication patterns across populations. Overall, the present study confirms that complications are a significant burden among diabetic patients, with diabetic foot, cerebrovascular issues, and retinopathy being particularly common. These results align with previous research,

though variations in complication frequencies highlight the importance of patient-specific factors and the need for early detection and management strategies.

The present study found significant differences in platelet indices between diabetic patients (cases) and non-diabetic participants (controls). Diabetic patients had higher values for mean platelet volume (MPV) at 6.73 ± 1.45 fL, platelet distribution width (PDW) at 10.4 ± 2.05 fL, and platelet large cell ratio (P-LCR) at 21.7 ± 4.43%. In comparison, non-diabetic participants had lower values for MPV (3.42 ± 0.45 fL), PDW (5.21 ± 0.57 fL), and P-LCR (10.8 ± 1.35%), with all differences being statistically significant ($p < 0.001$). Platelet counts were also higher in diabetic patients (257 ± 73.7 × 10^9/L) compared to controls (232 ± 45.1 × 10^9/L), with a statistically significant p-value of 0.015. The findings of the present study are partially consistent with those reported by **Dwivedi and Davangeri**,[27] who studied platelet indices among diabetic patients. Their study found higher values for MPV (8.6 ± 1.24 fL), PDW (17.9 ± 3.75 fL), and P-LCR (35.5 ± 7.88%) compared to the current study's diabetic cohort. However, platelet counts in the present study (257 ± 73.7 × 10^9/L) closely align with Dwivedi and Davangeri's findings (257 ± 75.6 × 10^3/μL). Differences in MPV and PDW may be due to variations in laboratory techniques or patient demographics. Similarly, **Taderegew et al.[28]** reported higher MPV (12.3 ± 2.2 fL), PDW (15.5 ± 2.5 fL), and P-LCR (25.4 ± 7.1%) in Ethiopian diabetic patients compared to the current study. Their study also recorded a slightly higher mean platelet count (266.5 ± 51.5 × 10^9/L). These variations suggest regional differences in platelet indices, possibly due to environmental or genetic factors. Overall, the present study confirms that diabetic patients exhibit elevated platelet indices compared to non-diabetic controls. Although the absolute values vary across studies, the trend of increased MPV, PDW, and P-LCR

in diabetic individuals is consistent, supporting the use of these indices as potential biomarkers for diabetes-related complications.

The present study found that diabetic patients with poor glycemic control exhibited significantly higher platelet indices compared to those with good glycemic control. Mean platelet volume (MPV) was 6.97 ± 1.35 fL in poorly controlled diabetics versus 3.55 ± 0.59 fL in those with good control ($p < 0.001$). Similarly, platelet distribution width (PDW) was elevated in the poor control group (10.8 ± 1.81 fL) compared to the good control group (5.4 ± 0.81 fL) ($p < 0.001$). P-LCR also showed a significant increase in the poor control group (22.4 ± 4.06%) compared to the good control group (11.3 ± 1.85%) ($p < 0.001$). Platelet counts were slightly higher in poorly controlled diabetics (256 ± 74.7 × 10^9/L) than in those with good glycemic control (236 ± 48.3 × 10^9/L), with a statistically significant p-value of 0.048. The present study's findings align with those of **Pujani et al.**,[25] who reported significantly higher MPV ($p = 0.000$) and PDW ($p = 0.003$) in diabetic patients with poor glycemic control (HbA1c >7%) compared to those with good control (HbA1c ≤7%). Although platelet counts in their study showed no significant difference ($p = 0.175$), the trend of increased MPV and PDW in poorly controlled patients matches our findings, reinforcing the association between poor glycemic control and altered platelet morphology. **Jiskani and Singh[31]** also found similar patterns in their study, reporting higher MPV (12.75 fL) and P-LCR (42.58%) in patients with good glycemic control, while patients with poor control exhibited reduced MPV (9.04 fL) and P-LCR (32.18%). However, their platelet counts were higher in the poorly controlled group (347 × 10^9/L) compared to those with good control (269 × 10^9/L), a trend similar to the present study, though with greater variance. In summary, the present study aligns with previous literature, showing that poor glycemic control is associated with elevated MPV, PDW, and P-LCR, indicating

increased platelet activation. These findings underscore the importance of monitoring platelet indices as potential biomarkers to assess glycemic control and predict the risk of diabetic complications.

The present study found that mean platelet volume (MPV) varied across age groups, with a general trend of higher MPV values in older participants. The highest MPV was observed in the 46–50 years group (5.68 ± 2.14 fL), followed by the 51–55 years group (5.40 ± 2.20 fL), and the lowest MPV was found in the 41–45 years group (4.51 ± 1.90 fL). MPV also differed slightly by gender, with males showing a slightly higher MPV (5.16 ± 2.07 fL) compared to females (4.95 ± 1.85 fL). However, the gender difference was not statistically significant ($p = 0.520$), suggesting no substantial variation in platelet size between males and females in the study cohort. The findings align partially with **Dwivedi and Davangeri**,[27] who reported a higher male-to-female ratio (2.82) among patients with complications compared to those without (1.30). Their study also noted a statistically significant association between gender and complications ($p = 0.018$), highlighting that males were more prone to diabetic complications. In contrast, the present study found no significant gender difference in MPV, though the slightly higher MPV values in males align with the trend reported by Dwivedi and Davangeri[27] In another study, **Shrivastava et al.**[32] examined MPV in 197 participants, including diabetic and non-diabetic individuals. They reported that the average age across their study groups ranged from 55.99 ± 10.45 years in non-diabetics to 58.34 ± 6.6 years in poorly controlled diabetics (HbA1c >7%). The present study observed a similar trend, where higher MPV values were more common in older participants (46–60 years), consistent with findings that platelet activation and size tend to increase with age. In summary, the present study confirms that MPV tends to increase with age but shows no significant gender-based differences. While previous studies suggest an association

between male gender and complications, the lack of significant MPV variation by gender in the present study suggests that gender may not play a decisive role in MPV changes among diabetic patients.

The present study found no statistically significant variation In platelet Indices with the duration of diabetes. The MPV was highest in patients with 1–5 years of diabetes (7.13 ± 1.84 fL) and slightly lower in patients with 5–10 years (6.68 ± 1.41 fL) and more than 10 years of diabetes (6.67 ± 1.35 fL), with no significant difference ($p = 0.657$). Similarly, PDW, P-LCR, and platelet counts did not vary significantly across these duration categories (p-values: 0.699, 0.695, and 0.259, respectively). These findings suggest that platelet indices do not substantially change with the progression of diabetes over time. The findings of the present study differ from those reported by **Dwivedi and Davangeri**,[27] who found significant positive correlations between platelet indices and the duration of diabetes. In their study, MPV ($r = 0.488$, $p < 0.001$), PDW ($r = 0.360$, $p < 0.001$), and P-LCR ($r = 0.415$, $p < 0.001$) were all significantly associated with longer durations of diabetes, indicating increased platelet activation over time. This discrepancy might be due to differences in study populations, sample sizes, or varying levels of glycemic control among participants. In contrast, **Kodiatte et al.[33]** found no significant correlation between MPV and the duration of diabetes ($r = -0.036$, $p = 0.585$), which is consistent with the present study's findings. Their results suggest that MPV may not always correlate with the length of time a patient has lived with diabetes, indicating that factors other than disease duration, such as glycemic control or comorbid conditions, may influence platelet indices more directly. In summary, the present study aligns with the findings of Kodiatte et al., showing no significant relationship between platelet indices and diabetes duration. However, it contrasts with Dwivedi and Davangeri's results, which found a significant positive correlation. These mixed

findings highlight the complex relationship between platelet activation and the progression of diabetes, suggesting that more research is needed to clarify the role of disease duration in altering platelet parameters.

The present study found significant differences In platelet Indices across different BMI categories. Obese individuals had the highest MPV (7.31 ± 1.46 fL), PDW (11.3 ± 1.19 fL), and P-LCR (24.6 ± 2.81%), with statistically significant p-values (MPV: $p = 0.004$, PDW: $p = 0.003$, P-LCR: $p < 0.001$). In contrast, normal-weight participants had lower values for MPV (4.92 ± 1.92 fL) and P-LCR (15.7 ± 6.07%), indicating less platelet activation. Platelet counts did not vary significantly between BMI categories ($p = 0.922$). These findings suggest a positive association between BMI and platelet activation, with higher platelet indices observed in obese individuals. The results of the present study align with the findings of **Biadgo et al.**,[34] who also explored the relationship between hematological indices and anthropometric measures in diabetic patients. Their study, however, found weak and non-significant correlations between platelet indices and BMI. Specifically, they reported r-values of -0.037 ($p = 0.659$) for platelet count, -0.123 ($p = 0.136$) for PDW, and -0.101 ($p = 0.224$) for MPV, suggesting that BMI did not have a strong influence on these parameters in their cohort.In conclusion, the present study supports the notion that obesity is associated with higher platelet activation, as indicated by elevated MPV, PDW, and P-LCR values. While Biadgo et al. reported weaker correlations, the current findings underscore the importance of monitoring platelet indices in individuals with higher BMI, particularly in diabetic patients, where elevated platelet activation can increase the risk of complications.

The present study found significan" dif'erences in platelet Indices based on HbA1c levels, reflecting the impact of glycemic control on platelet activation. Participants with HbA1c <5.6% had lower MPV (4.16 ± 1.62 fL), PDW (6.35 ± 2.41 fL), and P-LCR (13.3 ± 5.19%) compared to those with HbA1c levels of 5.6–6.4% (MPV: 6.88 ± 1.61 fL; PDW: 10.5 ± 2.59 fL; P-LCR: 21.4 ± 5.10%). Participants with HbA1c >6.4% exhibited similarly elevated indices, with MPV at 6.52 ± 1.42 fL, PDW at 10.3 ± 1.95 fL, and P-LCR at 21.4 ± 4.41%. However, platelet counts did not vary significantly across HbA1c groups (p = 0.250). The findings suggest a strong association between poor glycemic control and increased platelet activation. The findings of the present study align with **Pujani et al.**,[25] who reported that patients with HbA1c >7% had significantly higher MPV (p = 0.000) and PDW (p = 0.003) compared to those with HbA1c ≤7%. However, platelet counts did not differ significantly in their study (p = 0.175), consistent with the present study, which also observed no significant differences in platelet counts across HbA1c categories. Similarly, **Jiskani and Singh[31]** found that poor glycemic control (HbA1c >7%) was associated with lower MPV (9.04 fL) and P-LCR (32.18%) compared to those with good glycemic control (MPV: 12.75 fL; P-LCR: 42.58%). While their findings show an inverse pattern for MPV compared to the present study, both studies confirm that glycemic control strongly influences platelet behavior, as indicated by variations in platelet indices.In summary, the present study confirms that poor glycemic control, as indicated by higher HbA1c levels, is associated with elevated MPV, PDW, and P-LCR values, indicating increased platelet activation. These findings align with those of Pujani et al., while minor discrepancies with Jiskani and Singh highlight the complex relationship between glycemic status and platelet indices across different populations.

The present study found significant differences in systolic and diastolic blood pressure, as well as HbA1c levels, between diabetic patients (cases) and non-diabetic participants (controls). Systolic blood pressure was significantly higher in cases (145.79 ± 8.60 mmHg) compared to controls (119.61 ± 5.53 mmHg) ($p < 0.001$). Similarly, diastolic blood pressure was elevated in cases (88.99 ± 5.89 mmHg) compared to controls (76.79 ± 4.32 mmHg) ($p < 0.001$). HbA1c levels were markedly higher in cases (9.63 ± 1.85%) than in controls (4.78 ± 0.43%) ($p < 0.001$). However, no significant difference was observed in BMI between the two groups (25.3 ± 4.41 in cases vs. 24.08 ± 3.27 in controls, $p = 0.054$), suggesting BMI alone may not differentiate between diabetic and non-diabetic participants. The present study's findings align with those of **Demirtunc et al.**,[35] who found similar trends in systolic and diastolic blood pressure among diabetic and non-diabetic participants. In their study, patients with HbA1c >7% (Group B) had a systolic BP of 146 ± 21 mmHg and diastolic BP of 87 ± 15 mmHg, closely matching the blood pressure readings observed in our diabetic cohort. However, BMI in their diabetic groups (29.9 ± 5.5 kg/m²) was higher compared to the present study's cases (25.3 ± 4.41 kg/m²). **Pujani et al.[25]** also observed a significant difference in HbA1c levels between diabetics with (9.79 ± 2.24%) and without complications (7.85 ± 1.56%) ($p = 0.000$), consistent with the high HbA1c levels in the present study's diabetic cohort. However, they reported lower BMI values in both diabetic groups (22.71 ± 3.70 and 21.84 ± 3.73), suggesting that BMI might vary based on regional or demographic factors. In summary, the present study confirms that diabetic patients exhibit higher blood pressure and HbA1c levels compared to non-diabetic controls, consistent with findings from Demirtunc et al. and Pujani et al. Although BMI was slightly higher in cases, it did not reach statistical significance, indicating that factors beyond BMI, such as hypertension and poor glycemic control, are more strongly associated with diabetes.

The present study found significant correlations between HbA1c levels and platelet indices, while BMI showed weaker and non-significant correlations. MPV ($r = 0.967$, $p < 0.001$), PDW ($r = 0.982$, $p < 0.001$), and P-LCR ($r = 0.978$, $p < 0.001$) were strongly and positively correlated with HbA1c levels, indicating that poor glycemic control is associated with increased platelet activation. In contrast, BMI exhibited only weak correlations with MPV ($r = 0.111$, $p = 0.172$), PDW ($r = 0.117$, $p = 0.15$), and P-LCR ($r = 0.146$, $p = 0.072$), none of which were statistically significant. These findings suggest that while glycemic control has a significant impact on platelet indices, BMI may have a limited role. The results of the present study are consistent with **Shilpi and Potekar**,[24] who reported significant positive correlations between HbA1c and platelet indices (MPV: $r = 0.148$, PDW: $r = 0.171$, P-LCR: $r = 0.164$, all $p < 0.001$). Although the correlation coefficients were lower in their study compared to the present one, the trend of increased platelet activation with higher HbA1c levels remains consistent across both studies. Similarly, **Dwivedi and Davangeri**[27] found positive correlations between HbA1c and platelet indices (MPV: $r = 0.297$, PDW: $r = 0.204$, P-LCR: $r = 0.217$, all $p < 0.001$), supporting the association between poor glycemic control and elevated platelet activation. Additionally, they reported correlations between platelet indices and fasting blood sugar, LDL, and triglyceride levels, emphasizing the interconnectedness of metabolic parameters. In contrast to the strong correlations observed with HbA1c, both the present study and Shilpi and Potekar found weak or non-significant correlations between BMI and platelet indices, suggesting that BMI alone is not a strong determinant of platelet activation in diabetic patients. In summary, the present study highlights the significant association between poor glycemic control (higher HbA1c) and increased platelet activation, as indicated by elevated MPV, PDW, and P-LCR. These findings align with previous studies by Shilpi and Potekar and

Dwivedi and Davangeri, reinforcing the importance of glycemic control in reducing platelet-related risks in diabetes. However, BMI showed only weak correlations with platelet indices, indicating that obesity alone may not directly influence platelet activation, underscoring the primary role of glycemic control.

Conclusions

CONCLUSIONS

- The study found no significant differences in age ($p = 0.471$) or gender distribution ($p = 0.621$) between diabetic patients and controls, indicating well-matched groups.
- Smoking status was also comparable between the two groups ($p = 0.258$), minimizing smoking as a potential confounder in the analysis.
- Diabetic patients reported a significantly higher prevalence of common symptoms (e.g., polyuria, polydipsia) compared to controls ($p < 0.001$), highlighting the symptomatic burden of diabetes.
- The occurrence of diabetes-related complications (e.g., diabetic foot, retinopathy, nephropathy) was significantly higher in diabetics ($p < 0.001$), underscoring the need for proactive management strategies.
- Diabetic patients showed significantly elevated platelet indices (MPV, PDW, P-LCR) compared to controls, indicating higher platelet activation and potential vascular risk ($p < 0.001$).
- Poor glycemic control was associated with further increases in MPV, PDW, and P-LCR compared to well-controlled diabetics ($p < 0.001$), suggesting the impact of hyperglycemia on platelet function.
- MPV values varied slightly with age, but these differences were not statistically significant, indicating that platelet activation is relatively stable across age groups.
- No significant difference in MPV was found between genders ($p = 0.520$), suggesting that gender does not influence platelet size in this cohort.

- Duration of diabetes did not significantly affect platelet indices ($p > 0.05$), implying that the progression of diabetes alone may not alter platelet function.
- Obese individuals had significantly higher platelet indices (MPV, PDW, P-LCR) compared to normal and overweight participants, indicating a link between obesity and increased platelet activation ($p < 0.05$).
- Higher HbA1c levels were strongly associated with increased platelet indices ($p < 0.001$), suggesting that poor glycemic control is a key driver of platelet activation.
- Systolic and diastolic blood pressures were significantly elevated in diabetic patients ($p < 0.001$), reinforcing the association between diabetes and hypertension.
- A strong positive correlation was observed between HbA1c levels and platelet indices, indicating that worsening glycemic control increases platelet activation and vascular risks.
- BMI showed weak and non-significant correlations with platelet indices, suggesting that BMI alone may not have a significant impact on platelet function.
- The study highlights the potential utility of platelet indices as markers for assessing glycemic control and predicting vascular complications in Type 2 Diabetes Mellitus.

Limitations

LIMITATIONS

- The study design was observational and cross-sectional, which limits the ability to establish causal relationships between platelet indices and Type 2 Diabetes Mellitus (DM).
- The sample size of 152 (76 cases and 76 controls) may not fully represent the broader population, especially considering regional and demographic variations.
- The study focused on individuals aged 35 to 60, excluding younger or older populations, which may limit the generalizability of the findings.
- The inclusion criteria were restricted to age and sex-matched individuals with a diagnosis of Type 2 DM, which could introduce selection bias by excluding individuals with other health conditions or varying glycemic control.
- The exclusion of participants with other conditions such as coronary artery disease, malignancy, and thrombocytopenia could limit the applicability of results to the broader diabetic population, including those with comorbidities.
- The reliance on HbA1c as a measure of glycemic control may not fully capture fluctuations in blood glucose levels, potentially underestimating the variability in platelet indices.
- The study did not account for potential confounding factors such as diet, lifestyle, and medication adherence, which could influence both platelet indices and glycemic control.
- The cross-sectional nature of the study does not allow for the evaluation of changes in platelet indices over time or in response to interventions.

- The study’s use of a single blood sample for platelet analysis may not reflect the dynamic nature of platelet indices or their long-term fluctuations in response to glycemic control.

- The reliance on standard laboratory equipment and methods may introduce measurement errors or variations depending on equipment calibration and technical proficiency.

Summary

SUMMARY

In the study, “Evaluation of Platelet Indices in Type 2 Diabetes Mellitus,” the researchers aimed to evaluate platelet indices, such as Mean Platelet Volume (MPV), Platelet Distribution Width (PDW), and Platelet Large Cell Ratio (P-LCR), in individuals with diabetes and compare them to healthy controls. This study, based in Santosh Medical College and Hospital, Ghaziabad, included 152 participants (76 diabetic patients and 76 controls), focusing on the association of these indices with glycemic control and diabetes duration.

The study found that MPV, PDW, and”P-LCR were significantly higher in diabetics compared to non-diabetics, suggesting a prothrombotic state. Diabetics with poor glycemic control exhibited even higher platelet indices, highlighting the potential for increased vascular complications with poorer glucose management. The findings also illustrated that platelet indices were not significantly influenced by the duration of diabetes, but there was a notable variation in indices with glycemic control. Statistical analyses were performed using SPSS, with independent sample t-tests and correlation assessments to determine the relationship between platelet indices, glycemic control, and other factors.

Overall, the study reinforced the importance of monitoring platelet indices as part of the clinical management of Type 2 Diabetes Mellitus to predict and prevent associated vascular complications, especially in patients with poor glycemic control.

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Master Chart

MASTER CHART

S.NO	UHID	Diabetic or Non-Diabetic	Age	Age Range	Gender	BMI	BMI Category	Systolic BP (mmHg)	Diastolic BP (mmHg)	HbA1c levels	HbA1c	Platelet count (10^9/L)	MPV (fL)	PDW (fL)	P-LCR (%)	Glycemic Control Status	Duration of Diabetes (Years)	Duration of Diabetes (Years)	Diabetes complications	Common Symptoms
1	25795	Diabetic	54	51-55	M	32.9	Obese	133	94	11.9	>6.4	319	9.1	11.4	28.7	Poor	6.7	5-10	Diabetic foot	Malaise, Polyuria
2	10860	Diabetic	49	46-50	M	25.3	Overweight	142	88	12.3	5.6-6.4	283	8.9	14.1	31.3	Poor	10.2	>10	Retinopathy	Polyuria, Blurry vision
3	86820	Diabetic	43	41-45	F	29.8	Overweight	149	96	9.3	>6.4	190	5.8	11.2	21.4	Poor	7.1	5-10	Nephropathy	Weight loss, Weakness
4	64886	Diabetic	51	51-55	M	21.4	Normal	130	93	9.7	5.6-6.4	172	7.7	10.7	21.2	Poor	9.4	5-10	Absent	Malaise, Polyuria
5	16265	Diabetic	36	36-40	M	34.2	Obese	137	94	10.9	<5.6	237	6.4	11.6	25	Poor	5.9	5-10	Retinopathy	Polyphagia, Polydipsia
6	92386	Diabetic	52	51-55	M	26.3	Overweight	143	80	8	5.6-6.4	305	5.1	8.5	16.8	Poor	6	5-10	Absent	Polyphagia, Polydipsia
7	47194	Diabetic	50	46-50	M	24.2	Normal	145	82	8	5.6-6.4	304	5.9	7.7	19.5	Poor	8	5-10	Diabetic foot	Difficulty in breathing, Polyphagia
8	97498	Diabetic	50	46-50	M	27.9	Overweight	143	95	7.5	5.6-6.4	227	6.2	8.3	17.1	Poor	7.3	5-10	Nephropathy	Weight loss, Weakness
9	54131	Diabetic	39	36-40	M	21.4	Normal	141	90	8	<5.6	233	5.8	8.8	18.6	Poor	5.9	5-10	Retinopathy	Weight loss, Weakness
10	70263	Diabetic	40	36-40	F	20.4	Normal	148	91	7.2	5.6-6.4	111	5.4	7.9	15.8	Poor	12	>10	Multiple complications	Difficulty in breathing, Polyphagia
11	26023	Diabetic	57	56-60	M	32.7	Obese	152	89	9	<5.6	161	5.8	10	22.3	Poor	10	5-10	Diabetic foot	Malaise, Polyuria
12	51090	Diabetic	55	51-55	F	27.2	Overweight	144	95	6.6	>6.4	321	4.6	7.8	16.7	Good	4.3	1-5	Absent	No
13	77221	Diabetic	40	36-40	F	27.4	Overweight	157	87	11.7	<5.6	211	8.2	11.8	24.1	Poor	5.1	5-10	Retinopathy	Weight loss, Weakness
14	74820	Diabetic	50	46-50	M	29.6	Overweight	131	85	7.7	>6.4	181	5.4	8.9	14.9	Poor	5	5-10	Multiple complications	Polyphagia, Polydipsia
15	10769	Diabetic	50	46-50	M	26.9	Overweight	131	91	11.1	<5.6	335	8	12.5	25.1	Poor	6.8	5-10	Diabetic foot	Polyphagia, Polydipsia

16	69735	Diabetic	40	36-40	M	19.7	Normal	152	87	6.5	>6.4	341	4.7	6.7	14.4	Good	6	5-10	Absent	No
17	72955	Diabetic	59	56-60	F	28	Overweight	151	83	12.2	>6.4	222	9	12.8	29.7	Poor	7.6	5-10	Diabetic foot	Polyuria, Blurry vision
18	74925	Diabetic	43	41-45	M	24	Normal	148	87	11.6	>6.4	112	7.2	13.8	24.7	Poor	6.8	5-10	Multiple complications	Weight loss, Weakness
19	77969	Diabetic	46	46-50	M	20.3	Normal	154	97	11.8	5.6-6.4	261	8.2	14.4	28.9	Poor	2	1-5	Retinopathy	Malaise, Polyuria
20	15311	Diabetic	58	56-60	M	19.6	Normal	155	84	9.7	>6.4	321	5.8	9.3	19.8	Poor	5.9	5-10	Retinopathy	Difficulty in breathing, Polyphagia
21	93104	Diabetic	53	51-55	F	19.6	Normal	159	88	10.8	<5.6	299	7.8	12.8	23.9	Poor	7	5-10	Retinopathy	Difficulty in breathing, Polyphagia
22	63707	Diabetic	57	56-60	F	27.7	Overweight	158	83	7	5.6-6.4	170	4.6	7.4	15.1	Good	9.4	5-10	Absent	No
23	95305	Diabetic	37	36-40	M	29.4	Overweight	151	96	7.6	5.6-6.4	168	5.7	8.2	18.4	Poor	5.5	5-10	Cerebrovascular	Malaise, Polyuria
24	38693	Diabetic	47	46-50	M	29.2	Overweight	155	88	8.9	<5.6	383	5.9	9.3	21.1	Poor	3	1-5	Retinopathy	Polyuria, Blurry vision
25	81932	Diabetic	47	46-50	F	23.4	Normal	155	80	8	<5.6	269	5	9.8	17.9	Poor	1	1-5	Cardiovascular	Difficulty in breathing, Polyphagia
26	35658	Diabetic	40	36-40	M	26.3	Overweight	151	99	7.9	>6.4	303	5.2	8.5	16.6	Poor	6.8	5-10	Multiple complications	Weight loss, Weakness
27	94478	Diabetic	50	46-50	F	19	Normal	146	92	10.1	>6.4	160	7.3	11.4	24.1	Poor	5.6	5-10	Cerebrovascular	Polyuria, Blurry vision
28	28431	Diabetic	48	46-50	M	20.2	Normal	149	95	12.4	5.6-6.4	231	9	13.3	28.2	Poor	5.5	5-10	Multiple complications	Weight loss, Weakness
29	12747	Diabetic	37	36-40	F	21.1	Normal	139	92	9.4	5.6-6.4	205	5.9	9.6	21.1	Poor	5.1	5-10	Cerebrovascular	Polyphagia, Polydipsia
30	69150	Diabetic	36	36-40	M	24.8	Normal	135	93	11.1	5.6-6.4	229	6.4	10.7	23.3	Poor	6	5-10	Diabetic foot	Polyuria, Blurry vision
31	75725	Diabetic	46	46-50	M	18.5	Normal	144	82	7.4	<5.6	120	5.6	8	15.2	Poor	8	5-10	Diabetic foot	Difficulty in breathing, Polyphagia
32	94654	Diabetic	49	46-50	M	27	Overweight	151	85	8.1	>6.4	274	4.8	8.8	16.9	Poor	7.1	5-10	Nephropathy	Polyuria, Blurry vision

33	45773	Diabetic	45	41-45	M	29.3	Overweight	140	97	12	<5.6	250	8.6	11.9	27.1	Poor	6.1	5-10	Cardiovascular	Polyuria, Blurry vision
34	77435	Diabetic	42	41-45	F	27.7	Overweight	157	98	6.7	>6.4	320	5.3	7	16.4	Good	4	1-5	Absent	No
35	66886	Diabetic	52	51-55	M	21.3	Normal	134	84	10.6	>6.4	246	7	12.5	23.8	Poor	6.5	5-10	Multiple complications	Polyuria, Blurry vision
36	76803	Diabetic	50	46-50	M	33.7	Obese	130	94	11.7	>6.4	253	7.5	12.2	23.4	Poor	10	5-10	Absent	Polyuria, Blurry vision
37	41551	Diabetic	49	46-50	M	25.6	Overweight	137	81	10.7	<5.6	156	8.3	11.5	26.2	Poor	8	5-10	Retinopathy	Weight loss, Weakness
38	21394	Diabetic	59	56-60	F	26.2	Overweight	150	89	7	>6.4	184	4.5	8	15.3	Good	11	>10	Absent	No
39	79092	Diabetic	51	51-55	F	21.8	Normal	157	97	11	>6.4	389	7.6	11.4	23.9	Poor	2	1-5	Cardiovascular	Polyphagia, Polydipsia
40	13890	Diabetic	53	51-55	F	21.3	Normal	141	92	9.6	>6.4	297	7.3	11.5	23.3	Poor	5	5-10	Retinopathy	Malaise, Polyuria
41	51606	Diabetic	53	51-55	M	29.4	Overweight	141	84	10.2	>6.4	184	7.6	11.1	23.2	Poor	6	5-10	Diabetic foot	Polyuria, Blurry vision
42	90038	Diabetic	42	41-45	M	20.6	Normal	134	80	12.3	>6.4	308	9.8	13	25.7	Poor	4	1-5	Nephropathy	Difficulty in breathing, Polyphagia
43	97313	Diabetic	35	31-35	F	27.3	Overweight	136	80	11.3	<5.6	352	7.9	11.1	28.4	Poor	5.3	5-10	Multiple complications	Polyuria, Blurry vision
44	20627	Diabetic	57	56-60	F	24.5	Normal	133	97	7.7	<5.6	263	5.5	7.8	16.7	Poor	5.9	5-10	Cerebrovascular	Difficulty in breathing, Polyphagia
45	18792	Diabetic	38	36-40	F	27.6	Overweight	135	94	7.3	>6.4	342	4.4	8	15.5	Poor	5	5-10	Cardiovascular	Weight loss, Weakness
46	83969	Diabetic	46	46-50	M	34.8	Obese	142	96	12.2	5.6-6.4	305	9.4	13.3	25.7	Poor	2	1-5	Diabetic foot	Difficulty in breathing, Polyphagia
47	53001	Diabetic	57	56-60	M	29.9	Overweight	149	90	9.2	>6.4	301	6.4	9.9	22.1	Poor	6.2	5-10	Diabetic foot	Malaise, Polyuria
48	86552	Diabetic	49	46-50	M	33	Obese	159	96	11.3	>6.4	324	7.8	12	27.4	Poor	12	>10	Cerebrovascular	Polyphagia, Polydipsia
49	33897	Diabetic	49	46-50	F	19.5	Normal	144	92	12.4	5.6-6.4	362	9.8	13.8	28.7	Poor	5.4	5-10	Cerebrovascular	Difficulty in breathing, Polyphagia

50	78148	Diabetic	58	56-60	M	22.8	Normal	132	80	9.8	<5.6	285	5.8	9.6	22.9	Poor	10	5-10	Cerebrovascular	Difficulty in breathing, Polyphagia
51	33483	Diabetic	60	56-60	M	23.4	Normal	152	81	6.6	5.6-6.4	240	4.9	6.7	14.9	Good	8.8	5-10	Absent	No
52	58555	Diabetic	49	46-50	F	24.1	Normal	137	88	9.8	>6.4	289	6.1	11.4	20.8	Poor	10	5-10	Cerebrovascular	Polyphagia, Polydipsia
53	27159	Diabetic	40	36-40	M	19.8	Normal	149	82	11.3	>6.4	173	8.3	13.1	22.8	Poor	7.7	5-10	Nephropathy	Malaise, Polyuria
54	90077	Diabetic	40	36-40	M	31.5	Obese	145	80	11.2	>6.4	215	7.2	10.5	24.1	Poor	11.3	>10	Cerebrovascular	Polyuria, Blurry vision
55	45920	Diabetic	45	41-45	M	20.1	Normal	142	95	10.5	>6.4	246	6.6	11.5	26.5	Poor	6.6	5-10	Cerebrovascular	Difficulty in breathing, Polyphagia
56	77121	Diabetic	51	51-55	M	28.7	Overweight	147	85	11.4	5.6-6.4	222	7.5	13.1	23.2	Poor	3	1-5	Nephropathy	Polyphagia, Polydipsia
57	79479	Diabetic	35	31-35	F	21.8	Normal	157	96	9.1	>6.4	312	6.3	8.6	20.5	Poor	10	5-10	Retinopathy	Weight loss, Weakness
58	99475	Diabetic	52	51-55	M	29.8	Overweight	139	84	11.9	<5.6	355	8.5	13.3	28.9	Poor	7.2	5-10	Nephropathy	Polyphagia, Polydipsia
59	29457	Diabetic	42	41-45	M	18.9	Normal	159	84	7.8	<5.6	138	5.2	9.3	18.9	Poor	5.6	5-10	Cerebrovascular	Weight loss, Weakness
60	76557	Diabetic	59	56-60	M	28.1	Overweight	148	85	6.8	>6.4	227	5.3	7.1	14.9	Good	5	5-10	Absent	No
61	87189	Diabetic	57	56-60	F	25.2	Overweight	146	82	9.9	>6.4	229	6.6	10.7	25.4	Poor	5.2	5-10	Nephropathy	Malaise, Polyuria
62	88953	Diabetic	37	36-40	M	23.7	Normal	153	84	12.2	5.6-6.4	349	7.8	13.6	24.7	Poor	6.7	5-10	Multiple complications	Polyuria, Blurry vision
63	62995	Diabetic	48	46-50	F	28.4	Overweight	148	84	7.4	<5.6	208	6	8.8	19.1	Poor	12	>10	Cardiovascular	Polyphagia, Polydipsia
64	50757	Diabetic	37	36-40	M	23.5	Normal	157	89	6.7	>6.4	325	4.2	6.7	14.6	Good	6.3	5-10	Absent	No
65	19692	Diabetic	60	56-60	F	21.8	Normal	155	89	11.2	<5.6	283	8.6	11.4	23.6	Poor	5.7	5-10	Diabetic foot	Difficulty in breathing, Polyphagia
66	55758	Diabetic	43	41-45	F	31.4	Obese	152	98	8.8	>6.4	187	5.3	9.8	19.9	Poor	8.7	5-10	Diabetic foot	Malaise, Polyuria
67	82409	Diabetic	56	56-60	M	27.7	Overweight	155	96	11.1	<5.6	357	8.4	12.4	21.8	Poor	6	5-10	Diabetic foot	Polyphagia, Polydipsia

68	81211	Diabetic	54	51-55	M	29.3	Overweight	134	93	8.6	5.6-6.4	378	5.5	10.1	17	Poor	7	5-10	Cerebrovascular	Difficulty in breathing, Polyphagia
69	75697	Diabetic	41	41-45	F	29.3	Overweight	155	88	8	5.6-6.4	270	5.9	8.8	17.8	Poor	6.8	5-10	Diabetic foot	Polyphagia, Polydipsia
70	47065	Diabetic	41	41-45	F	27.7	Overweight	150	93	8.5	>6.4	202	6.4	9.4	20.6	Poor	5.3	5-10	Diabetic foot	Weight loss, Weakness
71	42606	Diabetic	59	56-60	F	25.4	Overweight	159	80	9.6	>6.4	139	8	10.4	21	Poor	1	1-5	Multiple complications	Polyphagia, Polydipsia
72	21534	Diabetic	56	56-60	M	18.6	Normal	152	98	11.5	>6.4	135	6.8	11.4	26.3	Poor	11.5	>10	Cardiovascular	Polyphagia, Polydipsia
73	50397	Diabetic	56	56-60	F	24.2	Normal	138	92	11.3	>6.4	334	7.5	11.5	26.9	Poor	12	>10	Multiple complications	Polyphagia, Polydipsia
74	11016	Diabetic	52	51-55	F	21	Normal	141	92	9.5	5.6-6.4	196	7.9	10.5	18.9	Poor	5	5-10	Cerebrovascular	Malaise, Polyuria
75	99789	Diabetic	59	56-60	F	18.7	Normal	150	83	8.1	>6.4	392	5.9	10.2	18.4	Poor	12.2	>10	Diabetic foot	Polyphagia, Polydipsia
76	65591	Diabetic	60	56-60	M	19	Normal	130	80	11	<5.6	334	8.2	11.9	22.3	Poor	6.8	5-10	Absent	Difficulty in breathing, Polyphagia
77	99812	Non-Diabetic	47	46-50	M	19.7	Normal	129	70	4.2	<5.6	158	3.2	4.9	9.8	Good			Absent	No
78	33247	Non-Diabetic	49	46-50	F	23.9	Normal	113	82	5.5	<5.6	293	3.6	5.7	13	Good			Absent	No
79	34300	Non-Diabetic	46	46-50	F	18.7	Normal	125	73	5.5	<5.6	174	3.9	6.2	12.3	Good			Absent	No
80	84065	Non-Diabetic	48	46-50	F	22.4	Normal	116	78	5.2	<5.6	199	3.5	5.8	12.2	Good			Absent	No
81	92798	Non-Diabetic	38	36-40	F	24.3	Normal	122	73	5.6	<5.6	298	4.6	5.9	14.3	Good			Absent	No
82	19268	Non-Diabetic	60	56-60	M	20.9	Normal	119	79	4.6	<5.6	257	2.9	4.8	10	Good			Absent	No
83	96807	Non-Diabetic	38	36-40	M	26.9	Overweight	116	72	5.6	<5.6	198	3.6	5.8	12.5	Good			Absent	No
84	22185	Non-Diabetic	57	56-60	M	22.1	Normal	123	78	5.3	<5.6	272	3.9	5.5	11.4	Good			Absent	No
85	73704	Non-Diabetic	57	56-60	M	27	Overweight	114	82	4.6	<5.6	278	3.5	4.7	11	Good			Absent	No
86	96779	Non-Diabetic	54	51-55	F	22.3	Normal	112	71	4.3	<5.6	173	2.9	4.2	9	Good			Absent	No
87	49099	Non-Diabetic	36	36-40	M	27.7	Overweight	120	84	4.9	<5.6	209	3.7	5.3	12.8	Good			Absent	No
88	18571	Non-Diabetic	44	41-45	M	27.8	Overweight	120	73	4.9	<5.6	228	3.3	4.8	11.9	Good			Absent	No
89	48044	Non-Diabetic	45	41-45	M	19.7	Normal	127	84	4.7	<5.6	255	3.2	5.9	10.5	Good			Absent	No
90	61214	Non-Diabetic	55	51-55	M	29.7	Overweight	124	75	4	<5.6	299	2.8	4.8	9.8	Good			Absent	No
91	71228	Non-Diabetic	51	51-55	F	27.1	Overweight	121	71	4.3	<5.6	267	2.7	5.2	10.3	Good			Absent	No

92	58984	Non-Diabetic	59	56-60	F	22.5	Normal	118	84	4.4	<5.6	174	3.2	5	11	Good			Absent	No
93	50774	Non-Diabetic	37	36-40	F	19.9	Normal	119	77	5	<5.6	215	3.2	5.1	10.9	Good			Absent	No
94	12568	Non-Diabetic	35	31-35	M	24.9	Normal	121	77	5.1	<5.6	236	4.1	5.5	11.6	Good			Absent	No
95	72592	Non-Diabetic	55	51-55	M	24.1	Normal	126	70	4.3	<5.6	190	3.6	4.7	10.3	Good			Absent	No
96	77563	Non-Diabetic	48	46-50	F	23.8	Normal	115	81	4.7	<5.6	276	3.5	5.6	10.8	Good			Absent	No
97	12695	Non-Diabetic	41	41-45	M	26.3	Overweight	116	72	4.5	<5.6	223	3.2	5.5	10.1	Good			Absent	No
98	58190	Non-Diabetic	46	46-50	M	18.5	Normal	123	79	4.2	<5.6	196	2.8	4.8	11	Good			Absent	No
99	15258	Non-Diabetic	37	36-40	F	20.5	Normal	122	78	5.2	<5.6	273	3.7	5.2	12.8	Good			Absent	No
100	97538	Non-Diabetic	60	56-60	F	24.9	Normal	117	74	4	<5.6	247	2.8	4.2	9.3	Good			Absent	No
101	49504	Non-Diabetic	41	41-45	M	29.9	Overweight	119	75	4.7	<5.6	283	2.8	5.3	9.4	Good			Absent	No
102	43159	Non-Diabetic	47	46-50	F	23.5	Normal	118	73	5.5	<5.6	244	4.4	6.1	14.5	Good			Absent	No
103	23986	Non-Diabetic	35	31-35	F	21.4	Normal	127	79	5.3	<5.6	275	3.9	5.6	12.6	Good			Absent	No
104	71858	Non-Diabetic	40	36-40	M	23.4	Normal	111	71	4.2	<5.6	250	3.3	4.5	8.1	Good			Absent	No
105	22666	Non-Diabetic	58	56-60	F	24.5	Normal	114	80	5	<5.6	238	3.9	6.4	13	Good			Absent	No
106	48660	Non-Diabetic	51	51-55	M	23.1	Normal	114	77	4.9	<5.6	255	3.4	5.6	11.3	Good			Absent	No
107	13561	Non-Diabetic	56	56-60	M	21.1	Normal	115	80	4.1	<5.6	201	2.8	4.3	9	Good			Absent	No
108	36854	Non-Diabetic	42	41-45	M	27.6	Overweight	128	82	4.9	<5.6	269	4	4.7	12	Good			Absent	No
109	74505	Non-Diabetic	57	56-60	F	27	Overweight	117	75	4.6	<5.6	218	3.4	4.8	10.8	Good			Absent	No
110	62251	Non-Diabetic	56	56-60	F	29.3	Overweight	125	74	4.5	<5.6	204	2.6	5	9.2	Good			Absent	No
111	32662	Non-Diabetic	43	41-45	M	26.6	Overweight	122	78	4.2	<5.6	221	2.5	4.1	9.3	Good			Absent	No
112	18392	Non-Diabetic	51	51-55	M	19.2	Normal	110	70	4.7	<5.6	283	3	4.9	11.2	Good			Absent	No
113	40535	Non-Diabetic	42	41-45	M	28.8	Overweight	129	74	4.4	<5.6	192	3.6	4.9	8.6	Good			Absent	No
114	88603	Non-Diabetic	40	36-40	M	21.6	Normal	126	75	5	<5.6	195	4.2	5.3	10.6	Good			Absent	No
115	62256	Non-Diabetic	38	36-40	F	29.2	Overweight	116	74	4.4	<5.6	210	2.8	5.3	9.9	Good			Absent	No
116	99135	Non-Diabetic	36	36-40	F	26.6	Overweight	122	75	4.4	<5.6	241	3.3	4.6	10.3	Good			Absent	No
117	45222	Non-Diabetic	45	41-45	M	22.5	Normal	113	75	4.1	<5.6	278	2.9	4.4	10.5	Good			Absent	No
118	87373	Non-Diabetic	38	36-40	M	29.3	Overweight	113	76	4.7	<5.6	204	3.6	4.9	10.6	Good			Absent	No
119	89575	Non-Diabetic	35	31-35	M	26.6	Overweight	115	73	5.3	<5.6	286	4.3	6.6	10.9	Good			Absent	No
120	94651	Non-Diabetic	60	56-60	F	23.1	Normal	128	83	5.2	<5.6	276	4	5.5	12.3	Good			Absent	No
121	73335	Non-Diabetic	44	41-45	M	26.3	Overweight	121	80	4.8	<5.6	160	3.5	5.5	10	Good			Absent	No
122	20965	Non-Diabetic	48	46-50	F	22	Normal	116	83	5.1	<5.6	209	3.7	6.4	10.8	Good			Absent	No
123	34538	Non-Diabetic	50	46-50	M	24.1	Normal	119	83	5.6	<5.6	222	3.6	6.6	12.4	Good			Absent	No
124	80592	Non-Diabetic	40	36-40	M	25.8	Overweight	128	83	4.5	<5.6	161	2.6	5.2	9.8	Good			Absent	No

125	18110	Non-Diabetic	51	51-55	F	28.4	Overweight	116	84	5	<5.6	250	3.7	5.5	10.2	Good			Absent	No
126	89309	Non-Diabetic	43	41-45	M	29.1	Overweight	112	77	5.1	<5.6	298	3.8	5.4	10.9	Good			Absent	No
127	37266	Non-Diabetic	47	46-50	M	22.3	Normal	122	76	4.4	<5.6	251	3.7	5.1	9.2	Good			Absent	No
128	62992	Non-Diabetic	59	56-60	F	21.6	Normal	122	78	4.6	<5.6	295	3.9	5.7	11.7	Good			Absent	No
129	92948	Non-Diabetic	44	41-45	M	26.3	Overweight	127	76	4.1	<5.6	244	2.7	4.8	9.1	Good			Absent	No
130	16910	Non-Diabetic	40	36-40	F	29	Overweight	129	72	4.8	<5.6	298	3.6	5.2	10.4	Good			Absent	No
131	10206	Non-Diabetic	48	46-50	F	19.2	Normal	117	72	4.9	<5.6	154	3.8	5.1	10.7	Good			Absent	No
132	97054	Non-Diabetic	38	36-40	M	21.6	Normal	118	84	4.2	<5.6	210	3.1	4.6	8.7	Good			Absent	No
133	97897	Non-Diabetic	37	36-40	M	23.7	Normal	116	77	5.5	<5.6	265	3.4	5.8	12.1	Good			Absent	No
134	33419	Non-Diabetic	38	36-40	M	22.8	Normal	110	74	4.7	<5.6	236	3.2	4.7	10.3	Good			Absent	No
135	60636	Non-Diabetic	41	41-45	F	23.5	Normal	112	73	4.8	<5.6	151	3.2	5.2	12.3	Good			Absent	No
136	60015	Non-Diabetic	57	56-60	F	20.9	Normal	122	77	4.7	<5.6	218	3.6	5.2	9.2	Good			Absent	No
137	64268	Non-Diabetic	41	41-45	F	21.4	Normal	126	84	4.7	<5.6	287	3.4	4.8	9.8	Good			Absent	No
138	97939	Non-Diabetic	36	36-40	F	18.9	Normal	110	75	4.9	<5.6	177	3.3	5.1	10.7	Good			Absent	No
139	28141	Non-Diabetic	58	56-60	M	26.2	Overweight	115	71	4.7	<5.6	283	3.4	4.9	11.5	Good			Absent	No
140	90356	Non-Diabetic	55	51-55	F	25.9	Overweight	115	73	4.8	<5.6	157	3.7	4.8	10.6	Good			Absent	No
141	81910	Non-Diabetic	46	46-50	F	22.9	Normal	121	81	4.7	<5.6	158	3.4	5.5	11.3	Good			Absent	No
142	66044	Non-Diabetic	35	31-35	M	28.9	Overweight	122	80	5.4	<5.6	293	3.2	5.5	11.7	Good			Absent	No
143	77214	Non-Diabetic	54	51-55	M	20.3	Normal	122	73	5.2	<5.6	277	3.8	5.4	13.2	Good			Absent	No
144	43827	Non-Diabetic	42	41-45	M	21.7	Normal	124	84	4.2	<5.6	265	2.9	4.7	9.2	Good			Absent	No
145	65820	Non-Diabetic	55	51-55	M	28.6	Overweight	125	75	4.9	<5.6	269	3.6	5.1	11.8	Good			Absent	No
146	72623	Non-Diabetic	44	41-45	M	20.7	Normal	120	75	5.1	<5.6	273	3.4	5.2	10.1	Good			Absent	No
147	91734	Non-Diabetic	58	56-60	F	18.8	Normal	114	70	4.6	<5.6	244	3.6	4.8	10	Good			Absent	No
148	85450	Non-Diabetic	52	51-55	F	27.9	Overweight	113	83	4.3	<5.6	156	3.1	4.1	8.7	Good			Absent	No
149	32299	Non-Diabetic	43	41-45	F	23.4	Normal	112	77	5.5	<5.6	260	3.7	6.2	12.2	Good			Absent	No
150	53585	Non-Diabetic	43	41-45	M	25.6	Overweight	128	75	4.6	<5.6	171	3.5	4.9	11.1	Good			Absent	No
151	74044	Non-Diabetic	49	46-50	M	18.5	Normal	129	72	5	<5.6	211	3.6	5.8	9.6	Good			Absent	No
152	52557	Non-Diabetic	38	36-40	M	23.8	Normal	127	83	4.8	<5.6	154	2.9	5.1	11.4	Good			Absent	No

Annexures

ANNEXURES

PROFORMA

NAME- AGE/SEX-

REG NO.- DATE-

ADDRESS- CONTACT NO-

Presenting complaints, other significant history and Duration

COMPLAINTS	DURATION
Polyphagia (increase eating)	+/-
Polydipsia (increase thirst)	+/-
Polyuria (increase urination)	+/-
Weakness	+/-
Malaise	+/-
Difficulty in breathing	+/-
Weight loss	+/-
Blurry vision	+/-

Examination

Duration of Diabetes

Height

Weight

Conscious +/-

Oriented +/-

Temperature ^{o}F

Pulse /min

Blood Pressure mm of Hg

Respiratory Rate /min

Pallor +/-

Icterus +/-

Cyanosis +/-

JVP

Clubbing +/-

Pedal oedema +/-

Lymphadenopathy +/-

Nails

Chest

CVS

PA

CNS

Biochemical Profile:

CBC- Platelet count, MPV, PDW, P-LCR

HbA1c

सहमति पत्र

तारीख:

मैं_____ आयु_____ लिंग_____ " प्लेटलेट सूचकों का मूल्यांकन प्रकार 2 मधुमेह " अध्ययन में विषय बनने के लिए अपनी पूर्ण, मुक्त और वैध सहमति देता हूँ। मुझे डॉ _____ द्वारा अध्ययन की उद्देश्य, प्रकृति और विभिन्न प्रयोगशाला परीक्षणों के बारे में मेरी पूर्ण संतोष के साथ बताया गया है। मुझे अध्ययन की अवधि और अध्ययन अवधि के दौरान पालन किए जाने वाले निर्देशों के बारे में बताया गया है। मुझे समझ में आता है कि यह मधुमेह में प्लेटलेट सूचकों में परिवर्तन को जानने के लिए किया जा रहा है। यह हमें मधुमेह के जटिलताओं की भविष्यवाणी करने में मदद कर सकता है जितनी जल्दी हो सके। मैं अध्ययन के दौरान किसी भी समय अध्ययन से बाहर निकलने के अपने अधिकार के बारे में जागरूक हूँ।

विषय के हस्ताक्षर……..

अन्वेषक का नाम:

अन्वेषक के हस्ताक्षर……..

निष्पक्ष गवाह का नाम:

निष्पक्ष गवाह के हस्ताक्षर:……..

CONSENT FORM

I_____ age_____ sex_____ give my full free and valid consent to be subject in the study titled " **EVALUATION OF PLATELET INDICES IN TYPE 2 DIABETES MELLITUS**."

I have been informed to my full satisfaction by Dr _____ about the purpose, nature and various laboratory investigations for the study to be carried out. I have been informed about the duration of study and instructions to be followed during study period. I realize that this is being done for the sake of knowing the changes in the platelet indices in diabetes mellitus. This can help us in predicting the complication of diabetes mellitus as early as possible.

I am aware of my right to opt out of study at any time during the course of study.

Name:

Date: Patient/patient's relative's Signature or thumb impression

Place:

Name: Signature of treating physician

Date:

Place:

Name: Signature of witness

ETHICAL CLEARANCE

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(Established u/s 3 of the UGC Act, 1956)

F. No. SU/R/2023/2489[90] Dated: 26.09.2023

Subject: Grant of Ethical Clearance for **Thesis Protocol** Topic **"Evaluation of Platelet indices in type 2 diabetes mellitus",** submitted by **Dr. GEETANJALI YADAV,** MD/MS student of Batch 2022-2023, Department of **PATHOLOGY**.

*****

With reference to his/her request for grant of Ethical Clearance for the Thesis Protocol entitled **"Evaluation of Platelet indices in type 2 diabetes mellitus", Dr. GEETANJALI YADAV** is informed that the **Thesis Protocol** submitted by him/her was considered by the **Screening Committee** of the Santosh Medical College & Hospital in its meetings held on 17.07.2023 to 28.07.2023. The recommendations of the **Screening Committee** were considered in detail by the **Institutional Ethics Committee** in its meeting held on **23.09.2023** and the same was **approved** by the **Ethics Committee**.

He /She is informed accordingly for further necessary action.

[Dr. NARESH SHARMA]
REGISTRAR

SANTOSH "DEEMED TO BE UNIVERSITY" REGISTRAR GHAZIABAD, NCR DELHI

Dr. GEETANJALI YADAV
MD/MS student of batch 2022-2023
Department of PATHOLOGY
Email: y.geetanjali030@gmail.com

Copy to:

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2. The Dean, SMC&H
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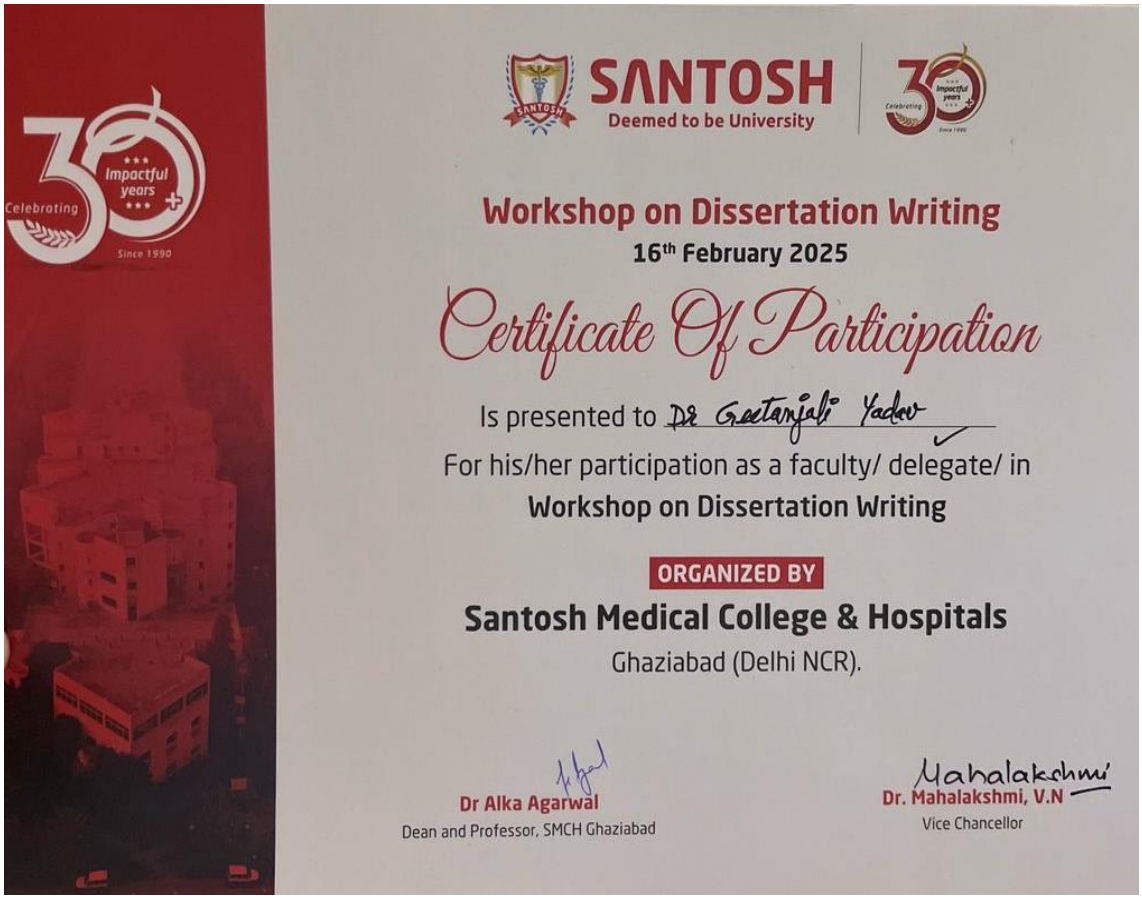

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Certificate Of Participation

Is presented to Dr Geetanjali Yadav

For his/her participation as a faculty/ delegate/ in
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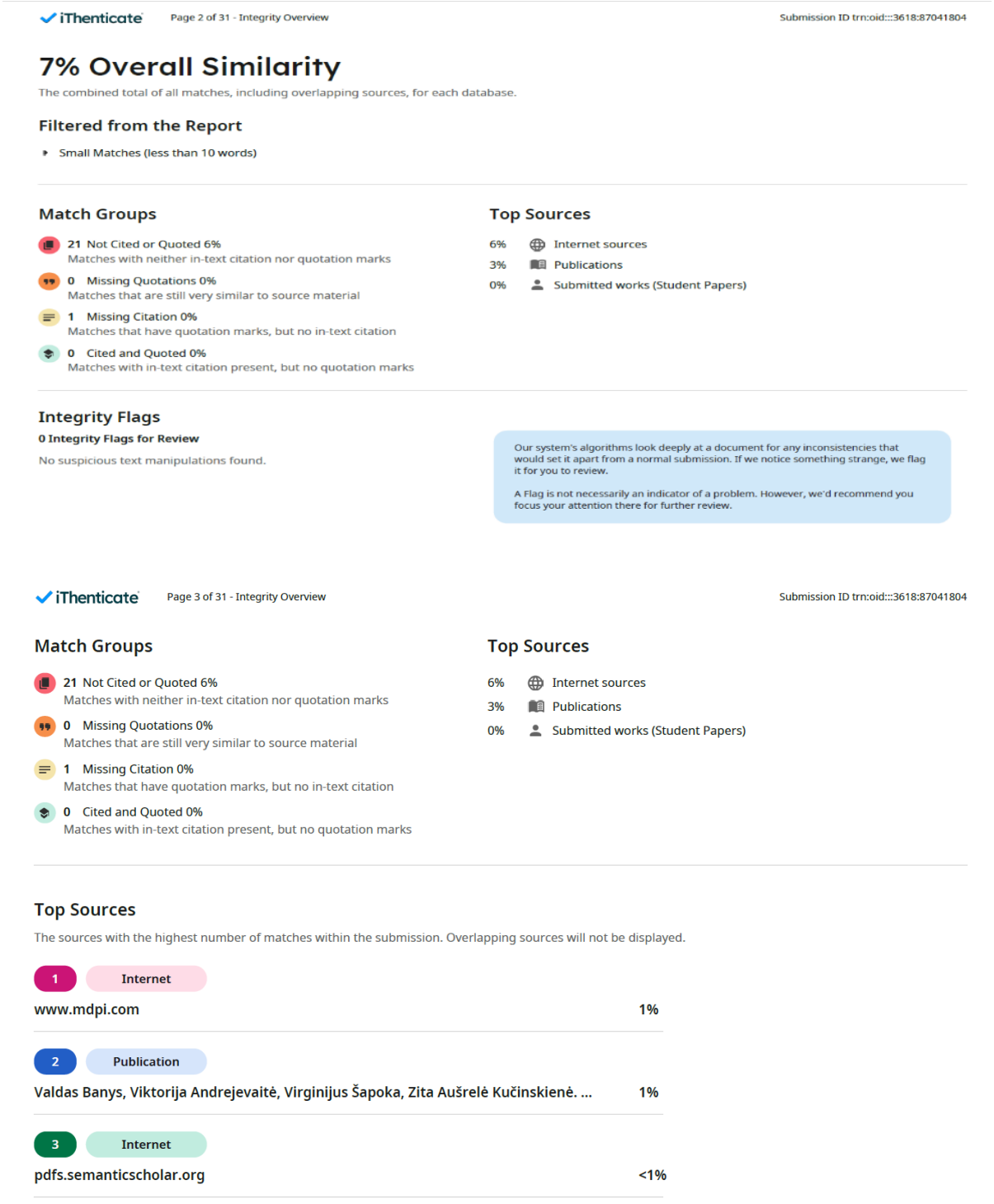

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